

REPORT
OF THE
USAR LAND RECLAMATION
COMMITTEE
UNITED PROVINCES
(1938-39)

Volume I



LAKHNAO:
LAND RECLAMATION, UNITED PROVINCES, INDIA
1940

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REPORT
OF THE
USAR LAND RECLAMATION
COMMITTEE
UNITED PROVINCES
(1938-39)

Volume I



ALLAHABAD:
SUPERINTENDENT, PRINTING AND STATIONERY, UNITED PROVINCES, INDIA

1940

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Report of the United Provinces Usar Land Reclamation Committee

INTRODUCTION

The *Usar* Land Reclamation Committee was constituted under the United Provinces Government Order No. 8486A/XXII-A—599, dated the 23rd November, 1938. The personnel and the terms of reference were as follows :

- | | |
|--|------------------------------|
| <p>1. Mr. V. N. Mehta, I.C.S., Junior Member, Board of Revenue, United Provinces ..</p> | <i>Chairman.</i> |
| <p>2. Mr. P. B. Richards, I.A.S., and later Mr. V. Sahai, I.C.S., Director of Agriculture, United Provinces</p> | |
| <p>3. Mr. E. A. Smythies, C.I.E., I.F.S., Chief Conservator of Forests, United Provinces ..</p> | |
| <p>4. Professor Bhola Nath Singh, D.Sc., Irwin Professor of Agriculture, University Professor of Plant Physiology, Head of the Institute of Agricultural Research, Benares Hindu University.</p> | |
| <p>5. Mr. M. Vaugh of the Naini Agricultural Institute, Allahabad</p> | |
| <p>6. Kr. Har Prasad Singh Sahib, M.L.A.; Banda</p> | |
| <p>7. Thakur Manak Singh Sahib, M.L.A., Advocate, Bulandshahr</p> | <i>Members.</i> |
| <p>8. Mr. Radha Mohan Singh, M.L.A., Ballia ..</p> | |
| <p>9. Khan Bahadur Mohammad Obaidur Rahman Khan, M.L.A., P. O. Habibganj, Aligarh ..</p> | |
| <p>10. Raja Jagannath Bux Singh Sahib, M.L.A., Taluqdar, 16 Clyde Road, Lucknow ..</p> | |
| <p>11. Mr. Mohsin Ali, I.S.E., Superintending Engineer, Irrigation Branch, United Provinces, Etawah</p> | |
| <p>12. Dr. N. R. Dhar, D.Sc., F.I.C., I.E.S., Deputy Director of Public Instruction, United Provinces, Allahabad</p> | |
| <p>13. Dr. B. K. Mukerji, Ph.D., D.Sc., Agricultural Chemist to Government, United Provinces, Cawnpore</p> | <i>Member and Secretary.</i> |

Terms of reference—(a) to examine and report on the suitability of the different methods advocated for the reclamation of *usar* land, with special reference to the use of molasses;

(b) to advise about the measures necessary to reclaim *usar* tracts for progressively rendering them fit for raising (i) food crops, (ii)

fodder crops, (iii) grasses, and also to consider the advisability of afforestation in areas which, although classed in Land Records as 'culturable', cannot be brought under cultivation;

(c) to devise means for preventing deterioration of arable soils into *usar*;

(d) to consider and report on any other important questions relating to the utilization of *usar* land; and

(e) to advise about the lines on which research and experiment should proceed in order to devise economical and effective methods of *usar* reclamation and further to consider the possibility of utilising the service of research workers in the universities in this work.

2. Meetings—The Committee held five meetings—the first being at Allahabad on the 9th and 10th January, 1939; and the others at Lucknow on the 22nd February; 14th and 15th April, 16th and 17th October and the 25th October, 1939.

3. Area of *usar* and other waste land—The Committee after considerable discussion came to the decision that in the loose way in which the term 'usar' was used in village parlance, it included some of 'culturable waste other than the current fallow', which, according to the latest statistical information available, amounted to 9,890,955 acres, *vide khatauni head* 14(iii). But the alkali area, as reported by the Land Records Department, is included in *khatauni head* 15(iii)—'Otherwise barren', amounting to 5,092,439 acres. In all the total figure in which *usar* one way or the other is included stands at 14,983,394 acres. Of this according to a statement recently prepared by the Board of Revenue, the total area of 'usar' and 'reh' lands is 2,037,119 acres. Even allowing for variations in the figures, it is certain that the total area of culturable waste in the United Provinces is more than four times the area which can be classified as 'alkaline' or 'saline'.

In 1883, according to the statistics collected by the Director of Land Records, the total area of *usar* land in the province was 3,129,053 acres. This figures included only alkaline and saline areas, and in the light of the statistics recently available it is clear that the total area of such lands now stands at a lower figure than before.

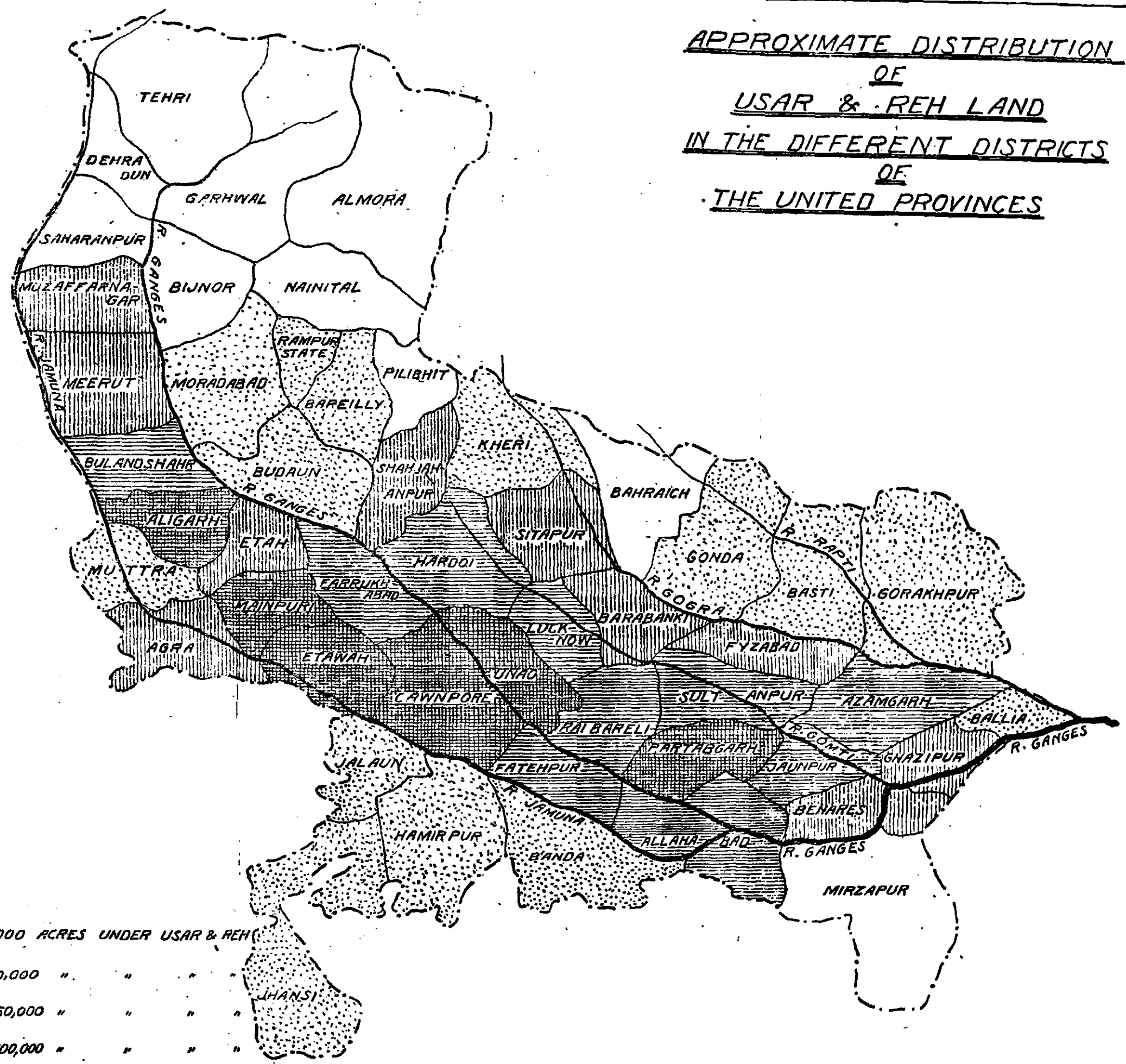
In order to visualise the magnitude of the problem the Committee examined the latest statistical report of the Land Records Department. Roughly stated, the total area of land in the United Provinces excluding the hill pattis of Kumaon stands at 6 crores of acres—(60 millions) classified as follows:

3·6 crores—Net cropped area.

26 lakhs—Current fallow.

3·86 crores.

APPROXIMATE DISTRIBUTION
OF
USAR & REH LAND
IN THE DIFFERENT DISTRICTS
OF
THE UNITED PROVINCES



DISTRICTS WITH 0-1000 ACRES UNDER USAR & REH
 " " 1000-10,000 "
 " " 10,000-50,000 "
 " " 50,000-100,000 "
 " " OVER 100,000 "

99 lakhs—Culturable waste popularly known as *Banjar*.

96 lakhs—Not available for cultivation—

(a) 27 lakhs—Covered with water.

(b) 18 lakhs—Sites, roads and buildings.

(c) 51 lakhs, —‘ Otherwise barren ’.

The ‘ otherwise barren ’ area in which 21 lakhs of *usar* land referred to above is included consists also of sandy areas, ravines and stony soils. It is possible—as shown further down—to reclaim some of these sandy and ravine areas which constitute at present a menace to established agriculture.

The area available for reclamation includes :

(1) “ Reh-encrusted *usar* ”, i.e. land which would show efflorescence of salts during dry weather.

(2) (a) *Usar*, i.e., land rendered infertile because of the relatively high percentage of alkali in the soil. The characteristic feature of this soil is that the surface is covered with a hard and compact crust having a dirty-white or dark-brown colour.

(b) *Usar* that has been rendered infertile on account of the presence of alkali salts in the sub-soil regions of the soil, i.e., where there is hardly any indication of alkali on the surface layer, but the soil underneath is distinctly alkaline.

(3) Land that has been rendered incapable of cultivation on account of—

(i) impermeability ;

(ii) removal of top layer by erosion resulting in ravine (*Behar* or *Khola*) areas ;

(iii) Water-logging ;

(iv) rocky or thin or sandy soil.

(4) ‘ Khadir ’ land where agricultural operations are rendered precarious on account of risk of inundation.

(5) Areas which are lying uncultivated on account of sparseness of agricultural population or scarcity of water.

Scope of enquiry—The extent of alkali or *reh* land in each district in the United Provinces is shown in the attached map. The Committee do not, however, attach much importance to the accuracy of these figures. In the absence of soil survey these can at best be rough estimates. Some of the area entered as ‘ barren ’ is reclaimable, because alkali and *usar* lands are included in this head ; while some of the culturable waste areas should really be relegated to the category of ‘ barren ’.

It was, however, felt that ‘ Usar ’ in the technical sense of the word could comprise only alkali and reh-encrusted land as described in (1), and (2) (a) and (b) above. The Committee are of opinion that by

confining their recommendations merely to the measures necessary for reclamation of *usar* soils it would be only touching the fringe of the problem of reclaiming culturable areas which are at present lying waste on account of their supposed infertile character. It is, therefore, considered necessary to ascertain whether Government would agree to the widening of the scope of the original terms of reference so that the problem of reclaiming land, other than alkaline or saline lands, could also be considered and comprehensive recommendations made on the subject. Government accorded their consent to the proposed widening of the terms of reference. The Committee also took into consideration the question of reclaiming *usar* areas and making them bear vegetation as a factor for checking the intensity of the incidence of floods. The Inter-Provincial Flood Prevention Committee recently constituted by the Governments of the United Provinces, Bihar and Bengal indicated in their report that a contributory factor to the causation of serious floods, specially in the eastern parts of the United Provinces, was the existence of an extensive area of *usar* in the Fyzabad, Azamgarh and Ballia Districts. In the light of this observation of the Flood Committee, it was considered desirable that this Committee should specially consider the effect of the existence of these enormous areas of 'usar' in the Province as factors for causing erosion, silting and rapid run-off tending to the incidence of heavy floods bringing in their train widespread devastation.

Résumé of technical work—At the outset, the Committee were faced with considerable difficulty in defining the exact connotation of the word 'usar' which is derived from the Sanskrit word '*ushtra*' meaning barren or sterile. The term 'usar' is extremely vague and covers a very wide range of soils. In common parlance, agricultural wasteland, soils only mildly alkaline or saline, soils which show very pronounced alkalinity, or soils with an efflorescence of *reh* on the surface are all comprised in the term 'usar'. It was, however, generally agreed upon that 'usar' may be defined as a degree of salinity or alkalinity in the soil too high to permit of the profitable growing of the usual food or fodder crops. The results of the analytical work carried out in the past by Dr. Leather and recently by Dr. Dhar and Dr. Mukerji reveal that in the United Provinces such conditions are mainly due to alkaline salts like sodium carbonate and bicarbonate, the exact quantity of which in the soil profile differs according to the nature of the soil and sub-soil, such as *kankar* beds and high water-table. Water-logging may be due to the impermeability of the sub-soil as with a heavy clay pan; to interference with the natural drainage of the area through construction of roads, railway embankments or to the raising of the spring-level through seepage from gravity flow canals. The extent of alkalinity also varies from a border-line pH value (degree of alkalinity) which will allow plant growth but renders agricultural operations precarious, to intense *reh* in which the salts come

up to the surface in dry weather as an encrustation, usually white and in which only xerophytic plants can survive. From the textural point of view, the soils either at the surface or at some depth below, within the zone generally occupied by roots, are found to be impervious. The profiles of these soils are generally associated with *kankar* or a definitely hard pan. The following views have been put forward to explain the formation of *kankar* :

(a) Due to the interaction of calcium chloride and calcium sulphate with the sodium carbonate present in alkali soils, calcium carbonate is formed. A small quantity of this calcium carbonate goes into solution with the soil water. The solvent action of this water is, however, enhanced by the presence of carbonic acid which is determined by the carbon dioxide present in the surrounding soil atmosphere. Calcium carbonate becomes easily soluble in water containing carbon dioxide as a result of the formation of acid carbonates or bicarbonates. In freely permeable soils the bicarbonate in solution usually finds its way with the gravitational water to the sub-soil water level and thus gets dispersed. But in the case of the impermeable alkali soils, the downward flow of the bicarbonate solution is considerably impeded, with the result that the bicarbonate tends to accumulate at a depth which is not far removed from the surface soil. Due to high temperature and generally arid conditions, the calcium bicarbonate is gradually decomposed to calcium carbonate, water and carbon dioxide, the calcium carbonate being deposited with the formation of a zone. The precipitated carbonate may cement the soil to almost the consistency of solid rock (i.e. hard pan) or form concretions, i.e. *kankar* or be deposited in fine grains between the soil particles, *bajri*.

(b) In addition to the view postulated above, there are theories of *kankar* formation based on (i) the decay of plant and animal remains in the soil and (ii) release of carbonate from supersaturated solutions.

Both the upward movement of water by capillary action and the downward flow of water under the force of gravity, by percolation, take place very slowly. Much of the intractable *usar* land in the United Provinces belongs to these classes. The alkali soils which in this province constitute by far the greater part of such intractable area have a strongly alkaline reaction and are in a deflocculated condition. They are characterised by the presence of sodium carbonate and bicarbonate in comparatively large quantities varying, as so far investigated, between 0.1 per cent. and 0.35 per cent. A number of profiles of such soils in different parts of the province has recently been examined by Dr. Mukerji. Their chemical and mechanical composition together with notes on their visual characteristics are given in detail in Appendix--Part I(3). The exact depth of the alkaline layer varies very

much in different localities. On an average it is found to extend to 3-4 ft. depth, although a few cases have been observed where the alkaline layer is continuous to a depth of about 6 ft. The alkali soils are further distinguishable by the differentiation in their structural profiles. Typically, the profile consists of a laminated superficial horizon overlying a deep layer showing a columnar or prismatic structure, usually grey or greyish-brown. According to the Russian system of pedological nomenclature, these soils can be classed as 'Solonetz'.

The area of predominantly saline soils in the United Provinces is certainly very much less than that of the alkali soils referred to above. So far saline soils have been come across only in certain areas of the Mat Branch of the Upper Ganges Canal.

Saline soils ('Solonchaks') contain mostly sodium salts like sodium sulphate and sodium chloride, and very little of sodium carbonate or bicarbonate. Contrary to the alkaline soils, the saline soils show an 'open' texture, and are in a state of flocculation. The case of the alkaline soils of the United Provinces is that a great majority of them are in an advanced state of degeneration. It is not uncommon to find the salt concentration in the deeper layers of the soil, making them impervious to water. When a soil is so impervious to water, the movement of water upwards during dry weather is small and it is consequently not possible for the salts to move very much. Hence, in badly alkaline soils general concentration of salts on the surface cannot be expected. Nor can the salts be expected to move down as the clay has so established itself as seriously to impede, if not inhibit, any movement downwards.

The morphology and the processes of formation of the alkaline and saline soils are as yet very little understood on account of absence of systematic pedological investigation. Even when some investigation has been made, the data so far available are too scanty to elucidate satisfactorily the fundamental points that face the scientific worker. The work by Dr. Leather shows, however, that the injurious salts, which are the decomposition products of igneous rocks under natural weathering processes, are present in the soil profile itself, and that they become evident on the surface layers under certain pre-disposing conditions like (1) arid or semi-arid climate; (2) an impervious sub-soil or hard pan; or (3) temporary abundance of humidity in the soil interspersed with dry periods.

The land of the province has generally a gentle slope from north-west to south-east. The northern districts are comparatively free from alkali. This perhaps may be attributed to the drainage effect of the Jumna River and partly to the underground drainage along the

slope, and to the removal of the alkaline surface soil to the lower regions. The north-eastern and south-western districts, namely Bahraich, Gonda, Basti, Gorakhpur, Jalaun, Hamirpur, Jhansi and Banda lying on this axis of drainage are comparatively free from alkali. It seems likely that the drainage action of the rivers Jumna, Gogra and Rapti plays an important part. A general view of the Gangetic alluvium of the province discloses the existence of extensive uplands free from alkali, followed by depressions, in which as a result of drainage accumulation and silting, heavy impregnations with alkalinity occur. The agronomist has also to take into account the cumulative effect of seepage water through ages from rivers and canals in areas lying between their channels in the southern parts of the province resulting in the rise of water-table and accentuation of salt incidence in the soil profile.

There is evidence to show that when the Western Jumna Canal was opened in 1820, irrigation on a large scale resulted in the formation of swamps and accumulation of *reh*. In the seventies of the last century Mr. Robert, a planter in the Aligarh District, petitioned the Board of Revenue for relief on the ground that he had suffered from deterioration of fertility of his land and that *reh*-encrustation had made its appearance since the settlement on some of his land. In 1876 and 1877 reports called for by the Board were received from the Collector and Settlement Officer of Aligarh. The Government sounded a note alarm at the 'extensive and increasing evil indicated by the reports before them', and it was desired that a detailed survey might be made into the causes of the increase of *reh* in the Sikandra Rao Tahsil and elsewhere through the Civil and Irrigation officers of the affected areas so that it might be determined once for all whether it was due to abuse of water-supply or to percolation from canals. In 1877 the Government directed that a Committee should be formed of the following members :

- (1) Mr. H. S. Reid, Member, Board of Revenue, President.
- (2) The Commissioner, Meerut ;
- (3) The Collector of Aligarh ;
- (4) Captain Howard, Executive Engineer, Aligarh Division, Ganges Canal ;
- (5) Mr. Smith, Settlement Officer, Aligarh ;
- (6) Mr. H. B. Medlicott, Superintendent, Geological Survey of India,
- (7) Mr. D. Ibbotson, Settlement Officer of Karnal, Punjab; and
- (8) Sir Edward Buck, Director of Agriculture and Commerce.

This Committee known as the 'Reh Committee' was the first attempt made in the United Provinces to investigate the problem of *usar* land reclamation. The terms of reference were restricted mostly to the question of reclamation in the Aligarh District ; but the findings of the Committee, although in certain respects untenable from the scientific and agronomic points of view, are of general interest.

The terms of reference of that Committee and their findings are given below :

<i>Term of reference</i>	<i>Recommendation</i>
(a) Has the water level risen and to what extent ?	There had been a considerable rise. Some measurements were made by members of the Committee from which it was evident that water was within 8-12 feet of the surface.
(b) Has the increase of <i>reh</i> been greater near the canal or at a distance from it ?	The Committee could not give a precise answer to this question without considering the conditions of tracts other than that inspected. It was recorded that no instance was known to any member of the Committee of serious extension of <i>reh</i> at a distance from a canal system.
(c) Has efflorescence of <i>reh</i> increased in tracts affected since the construction of the canal ?	Mr. Smith, who had inspected this tract for purposes of settlement about 7 years before, stated that he could notice a greater increase in surface efflorescence since he first visited it. Cultivators and zamindars universally testified to the same fact, and described areas of land now white with <i>reh</i> as having been covered with grass.
(d) Where <i>reh</i> has extended in cultivated land, is it always or usually in proximity to land previously affected ?	It was recorded that as a rule <i>reh</i> appeared to have extended within the tract under inspection in proximity to <i>usar</i> plains or old sources of <i>reh</i> , but contact with them did not appear to be a contributive factor to their causation.

- (e) Is there any connection between *reh* extension and natural drainage ?
The Committee were of opinion that the spread of *reh* occurred more often and more conspicuously in proximity to natural drainage lines, but that it did not necessarily always appear in connection with them.
- (f) Is the spread of *reh* more marked where drainage is obstructed than elsewhere ?
The Committee were unanimous in their opinion that obstruction of natural drainage, although not invariably necessary for the development of *reh*, yet always, within the tract under inspection, tended to produce conspicuous increase in *reh*.
- (g) Are there any instances and are they numerous or not, of *reh* spreading by shallow surface i.e., by being washed from a *reh*-affected area of land over an area not before affected ?
In the opinion of the Committee the extension of *reh* had been assisted by the above process.
- (h) Are there any instances in which *reh* appears to have been extended by the action of the wind ?
The Committee could not generally affirm that they had seen any such case, but two of the members believed that some cases of extension were due to *reh* being blown from a *reh*-plain over cultivated land.
- (i) Are there any instances in which *reh* extension appears to owe its origin to well water ?
The Committee could not find any definite instance of *reh* extension due to well water.
- (j) Are there any instances in which *reh* extension in cultivated land appears to owe its origin to *reh* brought by irrigation passing over *reh*-affected land ?
Some members of the Committee considered this circumstance to have been a minor cause of *reh* extension.
- (k) What are the conditions of *reh* formation ?
'Reh' is formed of "Highly soluble sodium salts, the result of the decomposition by air and water of the particles of rock-minerals to be found in almost every soil, being the waste product of soil formation the elements

unassimilated by vegetation—the gradual removal of which is ordinarily effected by the rain water draining through the soil and carrying with it any excess of these soluble salts."

The salts which form *reh* are found in most soils even where *reh* is not apparent on the surface.

A rise in the level of a main body of water underlying the surface is frequently accompanied by a greater development of *reh* at the surface and often in new places. These results may possibly be ascribed as well to an increase in the evaporating process due to the approach of the main body of water to the surface, as to a change in the geographical distribution of under-ground accumulation which with every change in level may find new centres of rest. The rise in water-table may also be attributed to the local obstruction of surface drainage.

For this a remodelling of the entire canal system in the affected parts appeared to be the most effective remedy. As an alternative it was suggested that deep drainage should be provided to keep down the water to some fixed level; to straighten the natural water drainage channels of the country; to provide embankments with the necessary culverts, and thus relieve waterlogging. Above all, the natural drainage of the country should be kept open and no dams or cultivation allowed in them.

The report of the Reh Committee gave an impetus to the work on *usar* reclamation in the United Provinces. Dr. J. Voelcker, who came out to India in 1896 on the invitation of the Government of India for reporting on the improvement on Indian agriculture, gave special attention to the question of reclamation of *usar* in this province. His report submitted in 1898 gave a résumé of the information about the reclamation work which was then in progress and contained suggestions for the future direction of the investigation. The Reh Committee was handicapped seriously for lack of precise scientific information on the nature of the *usar* soils and the pre-disposing causes leading to the formation of *usar* conditions ; but observations made by Dr. Voelcker filled up this gap partially, as he had been able for the first time in India to emphasise the importance of tackling the subject, not empirically but on scientific lines. His remarks which have special bearing on the subject before us, are summarised below.

According to Dr. Voelcker the origin of the injurious salts could be traced to the igneous rocks which as a result of gradual decomposition lead to the formation of these soluble salts. When the water which holds them in solution evaporates, they are subsequently deposited. It is interesting to note that for the first time it was indicated that the injurious salts were already present in the soil profile and were not of extraneous origin. It is only under some special conditions and as a result of action of peculiar natural force that these salts appear on the surface of the soil rendering it infertile ; that the salts may be brought to the surface depends on two conditions : firstly, water to percolate down to the sub-soil and to redissolve these salts ; secondly, a strong evaporative force such as the sun's heat to draw them out and up and bring about their crystallization on the surface. It was not possible for Dr. Voelcker, due to the absence of analytical data, to say either what amount of salts was met with in any particular soil, or what was the limit when in practice the salt was injurious ; also, whether the carbonate and the sulphate of soda could be taken to be equally injurious to vegetation.

Another point to which Dr. Voelcker directed attention was that *usar* areas could be reclaimed in parts by only simple process of enclosure and exclusion of grazing. He saw some experiments being carried out on these lines at Awa, district Etah, and was impressed with the value of this simple method. According to him "if cattle be kept off and be not allowed to nibble away every blade of grass as it appears, the worst *usar* will rapidly clothe itself with grass of any kind". Again, it was Dr. Voelcker who for the first time in this country indicated emphatically that in order to tackle the problem of *usar* effectively it was indispensable that there should be a complete analysis of the soils involved.

The lead given by Dr. Voelcker was followed by Dr. J. Walter Leather, Imperial Agricultural Chemist. During the years 1910-12 he carried out important investigation on different problems connected with the reclamation of *usar* land at three different centres, namely, near Bhadan in the district of Mainpuri on the Bhognipur Branch, Lower Ganges Canal; at Aligarh; and in Muttra and Etah districts.

The following conclusions emerge out of the work carried out by him at the three different centres :

I. Bhadan—

Estimation of moisture in several samples of soil revealed that the amount of moisture varied from about 5 per cent. in the first six inches of soil up to 20 per cent. at 5 or 6 ft. from the surface. Over-saturation occurred frequently at 6 to 7 ft. At 9 ft. from the surface the soils were found to be quite wet showing that the land was impervious to water at this depth which caused waterlogging. Tests for moisture content carried out at different periods of the year showed that the *usar* patch dried up at the immediate surface in dry weather, but from 12 inches deep down to 6 or 7 feet it remained as wet as at the end of the monsoon.

The 'alkali' in these soils (0'—6') consisted almost exclusively of carbonate, and the amount of chloride and sulphate was almost negligible—less than .005 per cent. The carbonate included both the normal carbonate and the bicarbonate. The amount of the two carbonates was usually found to vary between 0.1 and 0.2 per cent.

Nothing in the nature of a 'Saline-substratum' was met with. The alkali in the soil was considered to be the product of the soil itself. No appreciable concentration of alkali at the surface was noticed during the dry weather. Although some 'rise of alkali' towards the surface during the dry weather was inevitable, this was so small in these soils that it could not be measured.

It was found that water percolated through good soil at the rate of .0.3 to 1.0 cm. per hour. Tests made with Galpura and Surajpur *usar* soils showed that the rate of percolation of water through these was only 1/10th to 1/100th as fast as through good soil. These *usar* soils were found to be highly impervious at least up to a depth of 3 feet but beyond 6 or 7 feet they were as 'open' as the best arable land. It was therefore presumed that the impervious *usar* layer in the case of these soils was at least 6 feet thick.

Examination of non-canal-irrigated tracts showed that the sterile patches were as numerous and as similar as the patches in the canal-irrigated tracts. Canal irrigation, therefore, could not be held responsible for the formation of the alkali patches. The malaise was found

to be present in the soil itself in a latent form and the action of the canal water was to make it patent or, in other words, to accentuate the trouble.

It is generally assumed that canal water brings with it harmful ingredients and deposits them on the soil making it alkaline but the charge has not been proved. In good arable soils any accumulation of sodium salts will be washed away through natural drainage. In the impervious soils, however, slight additions may take place, but this is so small that years may roll on without producing the slightest effect. From an examination of the drainage water, it was proved that there was no lateral movement of water in these *usar* patches. It may, therefore, be concluded that canal water, even if it does add to the alkali, cannot induce it laterally and cause an extension of *usar*.

'The rate at which water will flow through these impervious soils has been measured and the conclusion drawn is that, assuming the sub-soil water level of this tract is first lowered, it might be possible to reclaim some of these lands by maintaining about 2 feet of water on the surface, but that the period required would probably be some 6 to 12 months. If the sub-soil water level cannot be lowered, then open drains or other artificial means of removing drainage water would be necessary. On the other hand, these *usar* patches are often so impervious to water that mere flooding would fail to be effective.'

In reference to this area the following remarks of Sir Bryce Burt will be found of considerable interest :

'When I visited Bhadan on the Bhognipur Branch of the Lower Ganges Canal with Dr. Leather many years ago, the fundamental trouble was waterlogging due in part at least to the blocking in of the natural drainage by a high level distributary which blocked the drainage to the Kala Nadi. One of our recommendations was that this distributary should be lowered and the tail converted to lift irrigation instead of flow. This would discourage over-watering also'.

II. Aligarh—

The main lines of Dr. Leather's enquiry and the conclusions obtained are summarized below :

Heavy doses of cattle dung (quantity not known) were applied to the *usar* land in the vicinity of Cherat and the land after some years began to produce good crops. Analysis showed that there was some downward movement of salts due to cultivation and irrigation, but the quantity of salt hardly showed any decrease even after years of such treatment. Less than 1 foot of the soil from the surface was changed physically and made freely permeable to water. The topmost

soil was thus reclaimed and the crops annually produced lived almost entirely on this stratum. The soil further down remained as bad as ever.

III. Etah—

The points studied were :

(i) How far does the nature of the *usar* patch situated in arable land which is under well-irrigation differ from similar patches on land under canal-irrigation?

(ii) Whether such *usar* patches become worse subsequent to the introduction of canals in that area?

The tract selected for the purpose of these investigations extended from Jalesar Road Station (E. I. Ry.) to Awa Khas, a distance of 20 miles, the first 10 miles being under well-irrigation and the later 10 under canal-irrigation. (Now these first 10 miles are irrigated by the Hathras Branch.) Twenty-nine patches were examined from each of the two tracts. The condition of crops in both the tracts was uniform. In regard to the impermeability of *usar* in the canal-irrigated area, it was less than that in the well-irrigated area. It is, however, interesting to note that in both the areas the soil was found to be equally impervious, irrespective of the system of irrigation and the depth of the water-table. Regarding salts, sulphate and chloride occurred in very small quantities in both the tracts. On the whole, the *usar* soil in the canal area contained rather slightly more carbonate than that in the well-irrigated area.

Taking the data as a whole no substantial difference could be observed in respect of frequency, infertility, nature and quantity of salts or physical condition between the soils of the patches which had been under canal-irrigation for many years and those which had only been under well-irrigation.

In the light of these observations, Dr. Leather remarked as follows:

‘It is very desirable that these *usar* patches should be tested again after the Hathras Branch has been in use for some years in order to gain decisive information regarding the question as to whether canal-irrigation does or does not occasion an increase in *usar* formation.’

10. The results of the analysis at various depths of the soil under reclamation at Aligarh as conducted by Dr. Leather are given below.

Soda salts present in part of Gursikran Reserve

Soils	Carbo- nate	Percentage of			Remarks	
		Sul- phate	Chloride	Total soda salts		
Samples of soil (first 2 feet) from four pits in a plot in Gursikran which was selected for treat- ment with gypsum.	I	.768	.045	.011	Samples taken in June, 1897.	
	II	.584	.037	.023		
	III	.789	.064	.046		
	IV	.477	.042	.043		
Land growing <i>dab</i> grass, surface to 2½ feet.	..		.023	.011	.034	
Land growing <i>dab</i> grass, 3 feet to 4 feet.		.065	.085	.029	.149	
Bare land, surface to 2½ feet.		.214	.274	.105	.593	
Bare land, 2½ feet to 4 feet		.272	.227	.181	.680	Samples taken in March, 1898.
<i>Gander</i> grass land, surface to 2½ feet.		.026	.054	.005	.085	
<i>Gander</i> grass land, 3 feet to 4 feet.	..		.056	.175	.231	
Bare land, surface to 2½ feet.		.582	.254	.210	.046	
Bare land, 3 feet to 4 feet		.321	.054	.081	.456	

The cause of barrenness in the above area was considered to be due to an impervious layer lying a few feet below the surface and also to the presence of high percentage of alkali salts in the soil profile.

11. Mr. W. H. Moreland, Director, Department of Land Records and Agriculture, published in 1901 a summary of the experiments conducted in the several parts of the province for the reclamation of *usar* lands. This is an extremely valuable résumé of the work which had till then been carried out by the Irrigation, Forest and Agricultural Departments.

One of the main objects with which *usar* reclamation was originally taken up in the province, had been to discover some means of utilizing the barren lands for supplementing the insufficient supplies of fodder. Accordingly, considerable attention was given to the study of the grasses which grew or could be produced on such barren lands. This research work was mainly in the hands of Mr. J. B. Duthie, F.L.S., Director of Botanical Department of Northern India. From the outset it was found that enclosure was essential for the proper growth of grass. The close grazing which is universal in these provinces and which must be expected to continue so long as land is left

unenclosed is fatal to the proper growth or extension of herbage, the young shoots of grass being nipped off and the tender roots destroyed by the hoofs of the animals.'

12. The following grasses were mentioned by Mr. Wilson to be growing on the *usar* areas :

(a) Khar *usar* (*Sporobolus arabicus* Boiss) the usual grass which develops greatly as an immediate result of enclosure.

(b) Bhurburui (*Sporobolus coromandelianus* Lint) which comes up in the rains but dies away quickly and gives little fodder.

(c) Dab (*Eragrostis cynosuroides* Beauv) which appears on rather better patches, and is of some use for thatching but of little value for fodder.

(d) The well-known dub (*Cynodon dactylon* Pers) which is found in depressions where the water lodges and spreads when the land is flooded with canal water.

Observations of the plots under operation at Awa showed that the result of enclosures was that land previously bare became covered with a crop of *Sporobolus arabicus*, and that better grasses showed a tendency to spread when protected from grazing. As the result of these observations, hopes were entertained that by the mere process of enclosing *usar* and planting trees on the better portions, efficient reserves for the supply of fodder and fuel could be secured at a profit, or at least without serious direct loss. Large schemes were formulated dealing with as much as 100,000 acres, but eventually 4 plots were taken up for further experimentation, namely, Juhi and Amarmau in the Cawnpore District and Gursikran and Cherat in the Aligarh District. The history of the Juhi and Gursikran enclosures is briefly as follows.

13. In 1890, after 8 years' enclosure, the results were considered disappointing. The staple grass (*Sporobolus arabicus*) which dies down after the rains, and which though largely eaten by animals, did not possess a high coefficient of nourishing value. Another species of grass somewhat more nutritive (*Chloris virgata*. SW) was also found to grow abundantly. Dub grass (*Cynodon dactylon*) did appear, but in general did not flourish well.

The Gursikran enclosure differed from Juhi in having been much more affected with alkali. After five years' experiment it was found that large areas of the land could grow *Sporobolus arabicus* in great luxuriance unmixed with any kind of vegetation. Some of the blocks were also entirely bare and covered with *reh*, others contained nothing but *usar* grass; whilst in others there was mixed vegetation, including various sized patches of *dub* grass.

14. As regards the reclamation of *usar* areas for tree planting the following conclusions were arrived at by Mr. Moreland :

(1) No method of sowing seeds on tilled *usar* land can yield a profitable growth of wood.

(2) Sowing on ridges is equally unsuccessful.

(3) Planting out young trees is a failure wherever the hole in which they are planted has a layer of *kankar* or a compact stratum of very hard clay.

In all these cases, the main cause of failure was identical. If the seed was able to germinate or the young plant to start growth, things went well until the roots had passed through the tilled soil or the earth filled into the hole ; but when the roots struck the hard clay or the *kankar* layer, they were found to be unable as a rule to penetrate the compact mass which was particularly impermeable to air and water. The necessary conditions of root development being thus absent, the tree died. Wherever trees survived it was observed that the roots found cracks or fissures in the hard sub-soil and penetrated to the much more congenial soil below.

15. Deep *thala* system—Consideration of this nature led to the adoption about 1895 of the method of planting which has come to be known as the “Deep *thala* system”. As originally introduced, this system required that the holes should be from three feet to four feet deep, and should be filled in with earth free from alkali and mixed with manure. The surface should be raised about a foot above the ground level, and healthy seedlings planted out and carefully tended and watered for the first year. Later experience goes to show that no limit should be prescribed for the depth of the holes : this must be determined by an examination of the sub-soil, and the holes must be dug through the heavy clay, so that the roots can penetrate to the coarser material lying below, which is to some extent permeable by air and water.

16. After Dr. Leather’s departure from India, Dr. A. E. Parr, Deputy Director of Agriculture, continued to carry on fairly intensive investigation in regard to the reclamation of *usar* patches in the Aligarh and Muttra Districts. The earliest attempts on a field scale proved a failure owing to ‘many difficulties’, the only possibility of doing anything appearing to be that of sowing the seed of such trees as *Babul* and *Dhak* and letting them take their chances, without going to any expense, in such patches of ground which the presence of *dab* indicated as less affected than the rest. Later on it was realized that for the purposes of planting trees with any certainty of success an exit must be made through the impermeable clay or *bajri* layers both for root development and drainage, i.e., the Deep *thala* system’. These holes were planted with different kinds of trees, namely, *Dhak*,

Babul, Jhand, or Chokra (Prosopis spicigera). The results, however, did not ultimately prove a success.

The results of the following three experiments which were also tried are given below :

(i) *Scrapping off reh.*

This method did not prove a success.

(ii) *Application of lime and gypsum.*

Application of lime alone did not bring about very satisfactory results. Gypsum was found to be very useful, but financially the experiment proved a failure.

(iii) *Planting of two varieties of Australian salt bush.*

These died every year during the rains and seed was collected for future propagation. They failed to stand the hot weather on *usar* land unless regularly watered. Waterlogging also proved fatal.

A number of fruit trees, viz. mango, *bel*, *jamun* and tamarind were also planted.

None of these flourished well excepting tamarind which proved somewhat better than the rest.

A number of plots were surrounded by banks flooded and kept under water for several months. The water was then drained off and a crop of transplanted rice was grown. It grew extremely well and a high yield of straw and grain was obtained. After rice was harvested, barley was sown and a good crop resulted. This method was continued successfully for several years and the milder types of *usar* could more or less be permanently reclaimed.

17. Mr. Hutton, Chief Engineer, Irrigation Branch, expressed in 1913 the following opinion in reference to Dr. Leather's findings at Bhadan :

'There can be no doubt that the introduction of the canal has raised the spring-level in this neighbourhood to some 40 or 50 feet. The spring-level even in the month of May is now from 8 to 10 feet below the surface and therefore well within the influence of surface vegetation.

'In a somewhat similar tract in California experiments proved that the ground water-level was not affected by surface evaporation at a depth below 8 feet.

'In the tract in question during the rains and specially during years of heavy rainfall, the ground water-level rose within a few feet only of the surface. Any measures therefore which can be undertaken to reduce the ground water-level must delay the deterioration of the tract in question.

'It is clearly desirable therefore to improve the surface drainage as far as possible in order to carry off the rain-water as quickly as possible'.

Mr. Hutton accordingly suggested that half the plot should be under-drained with tiled drains, say, not more than 3 feet below the surface in lines 50 feet apart, and the other half should be deep ploughed before flooding to induce rapid downward percolation. Four-inch colaba pipes could be used being laid with open joints.'

'A contour survey should be made of the ground water-level in this tract in the month of May.'

18. The following views were expressed in 1921, by Mr. A. W. E. Standley Chief Engineer, Irrigation Branch, on the reclamation of *usar* soils :

'A remedy for reclaiming *usar* soils, and one which is worked satisfactorily in America, is to get rid of salts by flooding combined with deep sub-soil drainage. Once the salts are worked out of the soil by this means, the evil is not likely to recur. If, however, the salts are only temporarily driven down by flooding not in combination with free sub-soil drainage, or buried by superimposed soil, given the same sub-soil moisture conditions, there is always risk of their re-appearance on the surface.

'After the drain pipes have all been laid, the tract should be constantly flooded for some months until the analysis of the seepage in the outfall drain shows that the salts have been considerably reduced. If pipes prove too expensive, a cheap alternative is to use small brushwood faggots in place of pipes or even open drains. In some of the tracts treated by this method in America, the flooding was continued for only one irrigation season, in others for two, but in both cases the considerable *usar* tracts treated were fully restored agriculturally to an equality with the best arable lands in the neighbourhood.

'Sub-soil drainage is, however, only possible where the *usar* soil is somewhat open. Generally *usar* land in the United Provinces is very impervious to water. Employing the two methods referred to above and taking percolation at 1/10th the velocity of ordinary soil, this percolation would be about 0.2 inch per day; in the solid this 0.2 inch would occupy a space equal to about 0.6 inch, hence it might be said that the first water would pass through 5 feet of soil in 100 days, by which time about 20 inches of water would have soaked in. In addition to this, there is evaporation to be considered. Taking evaporation at 0.2 inch per day throughout the year, which is equal to 20 inches for 100 days, forty inches of water in all would, therefore, be required on the surface before the first drainage occurred at 5 feet. Moreover, the salts would not be washed out until some considerable drainage had occurred, probably 10 inches, which would occupy another 50 days

and this would demand another 20 inches of water on the surface. If, however, the soil was more refractory and allowed water to percolate only 1/100th part as fast as through good soil, the water lost by evaporation would be 10 times that which is allowed for in the above calculation and time required would be 10 times as great. In short, whilst in the first example land might be reclaimed in six months, in the second 5 years would be required. For the purposes of above examples the impervious stratum of *usar* soil has been taken as 5 feet, but it must be understood that it is frequently of greater depth.

Another method of reclaiming land is by ordinary cultivation coupled with very heavy manuring. The quantity of manuring required for this method, is however, far in excess of what an ordinary farmer could afford. This method has been employed for several years in the Aligarh District but it has been found that even after years of this treatment, less than one foot of the *usar* soil has been changed physically and made freely permeable to water. In other words, less than one foot of the soil has been reclaimed. The crops which are produced live entirely on the reclaimed stratum, a conclusion which is supported by the fact that the crops required constant weekly irrigation.

Gypsum may also be employed to convert *usar* into good soil, provided a very large quantity of it is used and it can be brought into contact with the *usar* soil throughout its entire depth of several feet. Its effect is to convert the sodium carbonate contained in the *usar* soil into sodium sulphate and to coagulate the clay. The process is an expensive one as the quantity of gypsum required for the purpose amounts to tons per acre.

A system of reclamation which has been employed in the Punjab is to artificially increase the porosity and consequently the drainage of the impervious *usar* soil. This is accomplished by deep cultivation and mole draining which necessitate the employment of steam power. After the soil has been so lightened, water is applied which takes down the excess of saline matter in solution. This method aims at stopping the washing process after the excess of the mere soluble salts has been removed, thus leaving the land rich in those salts which constitute manurial constituents.

It is easy to account for the success obtained in America in dealing with *usar* soil, for from the method employed it is evident that sub-soil drainage is practicable. In India *usar*, as a general rule, in addition to being nearly impervious, is found in flat stretches of country not susceptible to sub-soil drainage within reasonable cost, and so far no method of practical utility has been discovered for reclaiming *usar* land in India. Obviously, if reclaimed land were extraordinarily valuable, it might be possible to free *usar* of its deleterious salts at a profit but that position is not yet reached in India, where culturable land is still available at a cheap cost.

19. The following summary by Mr. A. C. Laurie Chief Engineer, Irrigation Branch, on attempts at *usar* reclamation will help in understanding the results of the work carried out till 1924 in different parts of the province :

In the year 1918 Mr. Laurie visited the Government Farm, Aligarh, where over the last thirty years considerable amount of work had been done to reclaim the *usar* patches. What he saw was that in spite of what might have been given before the area presented 'as rank an instance of *usar* as could be found for miles around its vicinity.'

20. The only practical palliative according to Mr. Laurie was to lower the spring-level by restricting canal irrigation to a minimum or taking it away altogether, providing surface (not percolation) drains to prevent accumulation of water during the rains, and closing the canals as often and as long as conditions permit.

21. The historical review given above makes it clear that the problem of the reclamation of *usar* soils in the United Provinces has been receiving attention for the last sixty years. Although the investigation was neither continuous nor critical, it served a very useful purpose in indicating clearly the future line of research, both in the laboratory and on the field.

CHAPTER I

SUMMARY OF PRINCIPAL RECOMMENDATIONS

A. CHAPTER II—GENERAL AND RECLAMATION OF ALKALI LANDS.

Regarding legislative powers and organization for dealing with culturable waste and other waste lands generally

1. The Committee recommend that Government should take up legislation empowering Government to set up a provincial 'Waste Land Reclamation Board', District Statutory Authorities in districts and Local Statutory Authorities in villages with legal powers under the Act to deal with all types of waste lands generally with a view to their reclamation and improvement.

2. (a) The Committee recommend that the Government should set up a provincial Waste Land Reclamation Board to deal with all problems connected with the reclamation, improvement and conservation of waste lands generally. This would be the highest statutory authority under the contemplated Act.

The constitution of the Waste Land Reclamation Board would be as follows :

(1) Member, Board of Revenue—Chairman.

(2) Chief Conservator of Forests or his nominee.

- (3) Director of Agriculture or his nominee.
- (4) Chief Engineer, Irrigation, or his nominee.
- (5) Rural Development Officer or any other officer in future who would be discharging analogous duties.
- (6), (7) and (8) Government will select three experts.
- (9) and (10) Two members representing landed interests.
- (11) and (12) Two members selected from village organizations set up under the contemplated Act or under the Co-operative Societies Act to represent agricultural interests.
- (13), (14) and (15) Three members from the legislature will be elected on this Board. In all there will be 15 members including the Chairman.

The Committee recommend that there should be a whole-time man as Secretary who should be an agricultural expert. The above constitution of the Board was agreed to by all members, with the exception of Raja Jagannath Bakhsh Singh who disagreed as regards the question of the number of members representing landed interests. He was of opinion that there should be a majority of non-officials and specially the number of the zamindari community should be larger.

The provincial Waste Land Reclamation Board will be the ultimate authority that will be set up under the contemplated Act. Its powers will be as follows :

- (i) It will formulate the policy of land reclamation.
 - (ii) It will suggest how the funds provided by Government are to be utilized.
 - (iii) It will, under the various fund-raising provisions of the proposed Act, suggest the raising of funds for meeting expenses in connexion with reclamation of waste areas.
 - (iv) It will act as a controlling authority of the district authorities in the matter of carrying out the policy in detail in every district.
 - (v) It will be prepared to give advice to district authorities in carrying out any scheme of reclamation or improvement.
- (b) The 'District Authority' will be constituted as follows :
- (1) Collector of the district—*exofficio* Chairman.
 - (2) Chairman, District Board, or any organization to control rural areas that may be set up in its place.

(3) Two representatives of landed interests appointed by Government.

(4) Two representatives of tenants' interests selected preferably from the village organization set up under the contemplated Act or registered or recognized by the Co-operative Department and the rural development organization of the province to represent agricultural interests.

Technical experts of the departments of Agriculture, Forests, Co-operative and Irrigation will be nominated by the respective departments as members of the 'Authority' set up in the district. They will take part in discussion and offer their technical advice but will not vote.

(c) *Finance*—The Committee feel that a clear distinction must be drawn between works of reclamation which would involve a larger outlay of money and a return on the investment which can reasonably be expected to come back only after a lapse of some time and which in its scope would improve a waste area on a wide front, and works of improvement affecting restricted areas. The funds for the reclamation of the former type should, in the opinion of the Committee, be forthcoming mainly as a grant or partly as a grant and loan at a concessional rate from Government. As regards the expenditure necessary for works of improvement which affect a particular portion of a district or village the Committee recommend that approved works of improvements should be carried out with the active consent of the zamindars and cultivators, and assistance from Government, financial and technical, should be forthcoming. They recommend that when advances are given under Act XIX of 1883 or Act XII of 1884, the district 'Authorities' should be vested with discretion to recommend to the Board that the loan that should be given should bear interest at a concessional rate or should bear no interest at all and payment back of the loan should be spread over convenient instalments so that, as is the object of the Act, the loan charge could be met easily from the increased profits of cultivation.

The Committee are not in favour of acquiring outright any area for the purposes of its reclamation or improvement except under the Land Acquisition Act after going through full formalities under the Act. The land can only be acquired by Government.

The Committee are in favour of arranging for leasing out areas with the consent of zamindars and cultivators affected so that the area might be developed with due regard to the interest of everybody concerned from a loan borrowed under the above-mentioned Act or a grant made from Rural Development Funds.

The Committee lay emphasis on the fact that the work of reclamation and of taking necessary precautions to prevent erosion should be carried out by persuasion and active co-operation of the zamindar and the cultivators concerned. But where this active co-operation is not readily forthcoming and where the Board feel that in the circumstances stated under section 35 of the Forest Act it is necessary to impose certain line of conduct on the owner of the waste land by way of his taking positive action or refraining from acting in a particular manner, the existing powers of Local Government may be entrusted to the Waste Land Reclamation Board. Raja Jagannath Bakhsh Singh demurs to the above recommendation. He thinks that the power may remain vested with the Local Government as at present.

The Committee are agreed that where a scheme of reclamation or improvement is prepared with the help of experts by a village 'Authority' and the district 'Authorities' approve of the scheme, then the latter should be empowered to sanction any proposal forthcoming from the village organization for taxing itself to meet the cost of improvement or reclamation. The Committee at present are not in favour of vesting the district 'Authority' with the power of levying taxation on the villagers affected by the scheme of improvement unless the proposal comes by mutual agreement from the zamindars and cultivators concerned.

3. *Regarding the classification and better use of waste lands*—The proposed Board will consider the problem of the systematic survey of all types of waste lands and their proper classification. In particular they will consider the problem of classifying these waste lands into—

(A) Land which it is considered *economically* possible to bring under cultivation with prevailing conditions under which most agriculturists would be able to exploit such areas.

(B) Land which it is either physically impossible to cultivate, or whose cultivation would not be an economic proposition.

The Committee feel that it would be only after the scientific classification of waste land has been carried out that the most appropriate and economic remedies can be finally suggested for utilization of waste lands in order to add to the sum total of the requirements of the villager to feed himself and his cattle. It is, however, not to be understood for a single moment that the pace of reclamation of existing waste areas should be slackened pending the completion of the scientific survey. The known methods are to be impressed to the service of land reclamation so as to get the best out of land immediately.

4. In areas of type A, the Board will indicate the lines of economic reclamation, and will also indicate to what extent and on what lines the Departments of Agriculture, Irrigation and Forest will work.

5. In areas of type B, the Committee consider that these can best be tackled by the district statutory 'Authorities' working under the Board, with the technical advice and assistance of the Forest and Agriculture Departments for the checking of erosion, the improvement of fodder and grazing, and (where possible) creation of timber and fuel plantations.

Regarding 'usar' or alkali-infested lands—

(i) Where these fall into category A :

6. In areas where surplus canal water is available for leaching out harmful salts from the soil, the Committee recommend the continuance of the present joint action on the part of the Irrigation and Agriculture Departments.

7. Where canal water is not available, every facility should be given for sinking of wells and setting up of *bundhis* on contour lines for impounding rain-water.

8. The Committee recommend the Forest and Agriculture Departments to explore the possibility of working out appropriate types of saltworts suitable for our alkali soils which are rich in sodium carbonate and bicarbonate.

9. The Committee feel that the experience gained so far should be put into practice under the organization that has been outlined above, and are of opinion that the work of reclamation should not await till such time as a more scientific classification of the *usar* soils in the strict sense of the term has been brought about. The problem should be attacked from different directions on lines which are admitted to be empirical as well as on scientific lines.

10. Where *reh*-encrustation has been brought about by waterlogging due to the presence of canals in the neighbourhood, which have either interfered with natural drainage or wherefrom seepage water has added to the sub-soil water rendering the area waterlogged, the best method that the Committee would recommend is the one followed by the Irrigation Department, namely, construction of more shallow drainage cuts.

11. *Dealing with various methods suggested for reclaiming usar.*

(a) The Committee are not satisfied with the amount of evidence that electroculture has a direct bearing on opening out soil particles and making *usar* alkali lands less impervious to water. Unless and until further evidence is forthcoming on the connexion between electroculture and making the soil more porous, the Committee are not in a position to recommend this method for improving intractable alkali areas.

(b) American and European experience concentrates on the use of gypsum, sulphur, iron sulphate and alum. The Committee consider that these agents will generally be too expensive.

(c) As regards molasses, the Committee consider that further experiment should be made both by the Forest and Agriculture Departments so that the use of molasses as a reclaiming and fertilizing agent could be tested on more systematic lines. Wherever the cost would permit it, a mixture of molasses and pressmud in different proportions should be utilized for reclaiming alkali lands. This may be specially recommended for areas near sugar factories.

12. The Committee wish to stress the importance of improving the standard of feeding of village cattle. They recognize that *usar* land, if reclaimed and put under cultivation, can produce all varieties of crops including fodders and that a fraction of the area reclaimed will produce more fodder than is now secured. While the production of fodder should be increased, this should be done as part of a rotation involving the whole of the cultivated land and not by setting aside of certain areas for the exclusive production of fodders.

13. The Committee put on record their opinion that no administrator would be justified in treating these *usar* areas as if they were blocks available for planting an agricultural colony, possibly of landless labour. These areas are always to be considered as ancillary to the agricultural economy of the village, and they are to be developed with the one object of restoring the balance in the village economy. Every village ought to have its complement of cultivated land, grass land and forest.

(ii) Where these fall into category B :

14. The Committee suggest that the system of controlled rotational grazing by paddocks should be further explored by the Rural Development and Forest Departments.

15. The Committee also recommend that plantations of the nature of the successful Panchali plantation in the Meerut District should be more systematically undertaken, i.e. utilizing pockets of good soil in an *usar* tract for tree growth, and the surrounding *usar* land for improved fodder.

Regarding other types of waste land—

16. These mostly fall into category B, e.g. ravines, *bhur*, *khola*, waterless tracts like the Bhabar, malaria-infected zones like the Terai, rocky hills of the Sewaliks, Bundelkhand and Mirzapur, etc.

Where these are managed at present as forests under the Forest Department, the Committee consider that no further action is required.

Elsewhere the Committee consider that these can best be tackled as indicated in recommendation under paragraph 5 above. They want to emphasise what Mr. Smythies, the Chief Conservator of Forests has all

along urged, that what the villager needs is fuel to replace cow-dung, more fodder for his cattle and other vegetable refuse; that except in the Kumaun hills (where forests are close to villages) nowhere is vegetable matter available in sufficient quantities to meet the villager's needs, and that these unculturable waste lands should be managed so as to produce whatever vegetation they are capable of producing (trees, shrubs, grasses, etc.) to the maximum extent.

B. CHAPTER III—RECLAMATION OF OTHER WASTE LANDS

1. The Committee are of opinion that in spite of paragraph 100 of the Land Records Manual the patwari has neither the time nor the training to change the classification of land from culturable to barren and barren to culturable. They feel that the present area of nearly 79 lakhs under culturable waste is not a return of actual fact. With better classification of these areas in future based on instructions given to patwaris and trained field-men working in their collaboration, we hope to have a more accurate classification of soils which are waste and which the Waste Land Reclamation Board can systematically handle.

2. The Committee are emphatic that a policy of increased fodder production, use of labour-saving implements, more stall-feeding, and fewer but better cattle, is absolutely essential to break the vicious circle of insufficient fodder for large numbers of inefficient cattle, and land policy generally should be co-ordinated with that policy in view.

3. The Committee would emphasise that these waste lands will usually not be available for planting a colony of landless labour.

4. The Committee recommend that the fixing of sand-dunes, and the utilizing of sandy soils, as shown by Khan Bahadur Wahiduddin's experiment in Meerut District, should be more widely and systematically taken up in districts where similar conditions obtain.

5. The Committee make no recommendations regarding the Terai, as another Committee is at present sitting which will deal with and report on this matter.

C. CHAPTER IV—SOIL EROSION

1. The Committee recommend the extension of the work done by the Forest Department for the reclamation of Jumna-Chambal ravines by the method of (a) control grazing and (b) encouraging the growth of natural vegetation by sowing appropriate type of grasses, shrubs, trees and, where possible, food crops.

2. The Committee would recommend that, where a local authority is set up under the proposed Act, that authority will arrange for taking over leases of these areas from local zamindars on the condition that the area would be afforested with the technical advice of the Forest Department and at the end of a certain period returned to the

zamindars for the utilization of the afforested area according to the rules laid down by the statutory authority.

In the absence of an agreement, the Committee are, by a majority, of opinion that Government sanction should be obtained for compulsory leasing of these areas.

3. The Committee consider that the 'Authorities' set up in districts like Muttra, Agra, Etawah, Jalaun, Meerut, Muzaffarnagar, Bulandshahr and other districts which are affected by ravines, shall take comprehensive measures for the purpose of reclaiming these ravines on lines followed by the Forest Department.

4. The Committee have taken into consideration the matter referred to them by Government as to the action to be followed to reduce the crest and the erosive effect of floods. There are three zones to be considered :

- (1) the hills of Kumaun,
- (2) the ravines, and
- (3) the waste lands in general, and in Fyzabad, Azamgarh, Jaunpur and Ballia Districts in particular.

As regards (1), the Committee's recommendations are that no effort should be spared to prevent deforestation of the existing 2,000 sq. miles of Class I forests in the Kumaun hills.

As regards (2), the Committee endorse the opinion of the Chief Conservator of Forests that control of grazing in ravine areas will ensure better growth of natural vegetation, which would tend to check further gully formation and erosion and thereby reduce the crest of the floods and the run-off.

As regards (3), waste land in general, the Committee have submitted their proposals for their better utilization in this report. They wish to emphasise that with increased vegetation on these waste land areas, there is bound to be more absorption of rain-water and consequent reduction of the crest of the floods in periods of heavy rainfall.

5. The Committee suggest that the Revenue Department should revise all leases of Government land which have been given out on what is called jungle *tarashi* system, and a halt should be called to further deforestation in the interests of flood conservancy.

D. CHAPTER V—PREVENTION OF LAND DETERIORATION.

1. The Committee are of opinion that little attention has been given to soil conservancy, crop planning and crop production, and bring this important matter to the notice of the Revenue and Agriculture Departments.

2. The Committee have received evidence to show that desert conditions are tending to increase in certain areas in the Agra and Muttra Districts, and believe that a systematic policy of afforestation and construction of contour *bundhis* will possibly help to check this tendency.

3. The Committee draw attention to the useful work that has been done in the direction of *taungya* plantation, and recommend that this work should be extended as much as possible throughout the province, wherever possible.

4. The Committee recommend that tree plantations created by *taungya* on land which is subject to revenue should receive the same concession as regards the remission of revenue as areas planted under groves. The rights of planters of these trees will, subject to tenancy legislation, be governed according to agreement between the zamindars and planters of trees.

E. CHAPTER VI—INDUSTRIAL USE OF *reh*

1. The Committee cannot recommend that large-scale industry for production of pure carbonate of soda be set up in the United Provinces for purposes of purifying the available crude material. They consider that it is more economically utilized on a cottage industry scale, but the present system of collection should be improved.

F. CHAPTER VII—RESEARCH

1. The Committee would again emphasise the necessity of an improved method of soil classification of *usar* areas and other waste lands for the guidance of agriculturists and the Land Records staff. They consider that research is very necessary to establish and define this improved soil classification, and particularly to ascertain if variations of natural vegetation and soil types can be correlated. If this proves possible, the task of soil classification would be greatly simplified.

2. The Committee recommend that grants sanctioned by the Imperial Council of Agricultural Research on the basis of the scheme submitted by the Fodder and Grazing Committee for agrostological research be supplemented by Government so to enable research to be carried out in the laboratory and the field on the best method of growing improved grasses.

3. The Committee recommend association of a Soil Chemist, an Agronomist and a Physiological Botanist with the Waste Land Reclamation Board. They will have their appropriate subordinate staff.

4. The Committee are of opinion that the Waste Land Reclamation Board should seek the co-operation of university research departments in specific directions. The Board will allot particular problems

to the universities according to the facilities available by way of suitable staff and laboratory accommodation. Financial help may have to be given to these universities for carrying out specific research work. The Committee hold that the technique employed in the matter of soil investigation should, as far as possible, be uniform so as to enable the results obtained in different centres to be correlated and subjected to statistical tests.

5. The Committee are of opinion that in order to enable patwaris to do their work satisfactorily in the matter of soil classification, agriculture on the scientific side should be one of the subjects forming part of the patwaris' school curriculum and a refresher course be arranged in the Agricultural Schools for those patwaris who have not had previous training in agriculture.

6. The Committee are of opinion that care should be taken to see that the waste land that is reclaimed is not allowed to be fragmented below a certain minimum limit and Government may take steps as far as possible to prevent new fragmentation.

CHAPTER II

RECLAMATION OF ALKALI LANDS

The Committee fully realize that the practical avenue of approach to the immense problem of reclamation is not a straight one, and that there are many lines of ameliorative work all converging to the same point, namely, reclamation of *usar*. Our main advice, therefore, would be not to concentrate on any one line of approach but to start work on several lines. The field worker, in the telling words of Sir Bryce Burt, feels impatient because the scientist does not produce at once any practical and simple remedies for the many ills which afflict agriculture. Sir John Russell has also declared 'that the great need is now for the full use of existing knowledge rather than accumulation of more knowledge; for work on the cultivator's field than in the laboratory.'

While emphasizing therefore the necessity for concentrating on practical work, we cannot lose sight of the fact that a great deal of purely scientific work requires to be done in order to arrive at correct knowledge regarding the various types of *usar* soils with which the practical agriculturist will have to deal with in this province. Unless there is co-operation among all workers, both in the technical departments as well as in the universities, interested in the scientific aspects of waste land reclamation, the endeavours of the field worker will not bear the multifarious fruits which we expect him to produce for the villager. The Committee would emphasize the point that there is a

great deal of accumulation of knowledge about *usar* and the methods of its reclamation outside India. In India itself the science of pedology has not made much progress. We feel that the work of soil classification in the United Provinces as well as in the other parts of India, barring the Punjab and the Bombay-Deccan, is still in the initial stage. Some pedological work on hill fruit soils has, however, been carried out within the last three years at Chaubattia in the Kumaun hills. The Committee would recommend, on the basis of the historical résumé of the work done in the province in the past, that the line of approach to the problem should be a multi-linear one.

Before recommending any particular method it is necessary to take into consideration the great change which has taken place in our outlook on soil science since the last twenty years. In view of the results that have in recent years emerged out of the researches in soil science carried out in India and abroad, specially on the reclamation of alkali and saline soils in Hungary, the United States of America and Egypt, it is more important than ever that we should base our methods of reclamation on the nature of the *usar* in question and the predisposing conditions of *usar* formation. We should recognize and emphasize more than ever the dynamical character of the soil. In the words of Marbut: 'The soil consists of the outer layer of the earth's crust usually unconsolidated ranging in thickness from a mere film to a maximum of somewhat more than ten feet which differs from the material beneath it, also usually unconsolidated, in colour, structure, texture, physical constitution, chemical composition, biological characteristics, probably chemical processes, in reaction and morphology.' These points will be discussed in detail while dealing with the need for research and experiment. As is true with many other agricultural operations, *usar* reclamation at least in the United Provinces is definitely considered to be a problem, success in which cannot be achieved by one method of treatment resulting in complete and permanent change in the nature of the soil. Rather it is a process which will have to be carried on for a number of years resulting in somewhat gradual improvement of the soil, eventually leading more or less to complete reclamation. Even after the productivity of the soil has been brought to that of good soil in the neighbourhood, it may be necessary to continue to take precautionary measures lest the soil once reclaimed reverts again to infertility. Above all, the cost of reclamation has always to be kept in view. Therefore, the reclamation procedure and particularly the equipment required for it should, as far as possible, fit into the ordinary programme of agricultural practice followed by the cultivators of the area.

The question of *usar* reclamation on an all-India basis was considered by the Sub-Committee of the Crops and Soils Wing of the Board of Agriculture and Animal Husbandry in India in February,

1935. It was indicated that the problem of reclamation could be approached by three methods :

(i) *Mechanical*—The application of heavy doses of water to wash the salts down.

(ii) *Agronomic*—Growth of suitable crops in suitable rotations.

(iii) *Chemical*—Application of chemical correctives, e.g., gypsum, calcium chloride, etc. to the soil.

In practice, a combination of the mechanical and agronomic methods has been found most effective and economic. In general, the reclamation of *kallar* (saline) lands in Sind involves the concentration of the irrigation supply available to a holding on the portion under reclamation, followed by the cultivation of cotton in the *kharif* and barley and *berseem* in the *rabi*. Leachings with irrigation water are usually applied in four doses of 8 inches each at intervals of one week.

In the Punjab the earlier work on the reclamation of alkali land was carried out at Narwala, about 22 years ago, using simple leaching combined with deep cultivation with the aid of steam-tackle. The effect is still very marked as the land is all under normal supply of canal water.

The Punjab Irrigation Research Institute has carried out successful large scale experiments under strict chemical control on the reclamation of canal irrigated land which has gone out of cultivation due to excessive salinity associated with a marked rise in the sub-soil water level. The general method adopted involves the construction of deep drains around blocks of suitable size followed by heavy leaching combined with the application of gypsum. Cropping with rice is the next stage and this is an essential feature of the process. Leaching, with gypsum applications, is repeated until the yield of rice has attained a certain level so that the rice crop is used as an indicator of the progress of reclamation. The next stage is cropping with *berseem* followed by sugarcane or cotton.

As indicated above, notable work has been in progress both in the Punjab and Sind. It is, therefore, interesting to make here a somewhat detailed reference to the results achieved and the experiments in progress in both of these provinces.

The method followed in the Punjab for reclaiming saline soils on the Renala Farm is as follows :

The salt-encrusted fields are bunded up into $\frac{1}{4}$ -acre plots, and about six inches of irrigation water kept constantly standing in them. As soon as the conductivity reaches above 1,000, the water is changed by allowing to flow into a drain which surrounds the plots at a depth of about $1\frac{1}{2}$ feet from the surface. It is found necessary to continue leaching in this way for about one month to bring the salinity down

to a fairly low level, excepting in the case of heavy *thur* soils for which leaching is generally continued for about two months. Gypsum in the powdered form is then applied to the fields at rates varying between one and two tons according to the degree of alkalization of the soils. Generally leaching operations begin in the first week of April and rice is transplanted about the beginning of June. In moderately saline soils, usually only one crop of rice is found to be sufficient for satisfactory reclamation. If after the rice crop is harvested, the treated plots do not show any efflorescence till the middle of the following November, a crop of *berseem* or *senji* is taken, which is followed by cotton. In order to keep the cost of cultivation down, no manure of any sort is applied before *berseem* is sown. The stubbles of the preceding paddy crop constitute the only source of organic manure. If, on the other hand, the white encrustations reappear during the winter months, the plots are marked out for subsequent leaching and cropping with rice again during the next *kharif* season.

The saline soils of the Punjab and Sind are characterized by the presence of sodium sulphate in large quantities and are invariably found to be porous and extremely permeable to water. The soil profiles to a depth of 5 feet or so are found to be impregnated with salts and down below there is a layer of sand of varying thickness. In general, the water-table is at a distance of about 6 feet from the surface. In most cases the higher concentration of the salts (as is evident from the white efflorescence) does not extend to a greater depth than 2 feet from surface. The soil further down to a depth of another 3 or 4 feet is saline, although there may not be any efflorescence. Very often they show efflorescence right on the surface like *reh* in the United Provinces. The relieving features in the composition of such soils both in the Punjab and Sind are the almost entire absence of sodium carbonate and presence of comparatively high lime content in the form of calcium carbonate. In contrast with the conditions in the United Provinces another redeeming feature of these soils is the presence of a sandy layer in the sub-soils a few feet below the surface. This layer of the soil facilitates the penetration of water and subsequent washing down of the salts to the lower layers, and also serves as a barrier in preventing the return or rise of the salts to the surface when the salts have been once washed down. The coarser the sand, the more effective is the barrier.

It is, however, important to bear in mind that in spite of some apparent similarity between the saline soils in the Punjab and *reh* soils in this province, there is considerable fundamental difference in the nature of the two soils.

From the available analytical data regarding the soil profiles so far examined (*vide* Appendix I-3) it will be seen that in this province the soil underneath the efflorescence is usually very hard and compact,

and almost wholly impermeable to water ; but in the case of the Punjab saline soils, the soil beneath the efflorescence is extremely porous, and, therefore, permeable to water. Whereas, in the case of our *reh* soils it is a problem to get a few feet of the soil soaked with water, in the Punjab due to the extreme porosity of the saline soils much difficulty is experienced in impounding water on bunded fields. Due to this important difference in the nature of the soils it is obvious that a good deal of modification of the methods followed in the Punjab for successfully reclaiming saline soils would be necessary before they could suitably be applied for our *usar* or *reh*-encrusted *usar* soils. The saline soils in the Punjab are almost invariably found to contain sodium sulphate and it can be assumed that such soils develop in the process of evolution into alkali soils only if the soluble salts do not include calcium sulphate or calcium chloride.

There appears to be fundamental difference in the causes leading to *usar* conditions in the Punjab and Sind, and the United Provinces. In the Punjab and specially in Sind rainfall is scanty and not well distributed during the year and there are prolonged dry periods. The incidence of most of the saline and alkaline areas in the Punjab and the saline areas in Sind is chiefly due to intensive canal-irrigation which has resulted in considerable rise of the spring-level. Both in regard to this and climatic factors the conditions obtaining in the United Provinces are widely different from those in the other two provinces. In the United Provinces the earlier work of Dr. Leather and the more recent observations made by the Irrigation Branch preclude the theory that *usar* or *reh* formation is chiefly attributable to intensive canal irrigation. The alignment of our canals, being on the water-shed, does not as a rule interfere with the natural drainage of the country. Moreover, adequate drainage is provided—2 miles of drains for every 3 miles of channels. There are, however, certain areas specially on the Mat Feeder heavily infested with *reh*, the formation of which can be traced directly to seepage. This damage seems to have been caused by previous remodellings to enable the canal to carry greater supplies of water by the simple process of steepening the bed slopes by cutting down falls with only a slight widening of the canal. The result is that it induces too high a velocity leading to erosion of the bed and sides, and tearing away of the impervious silt lining. The Mat Branch was constructed in the fifties of the last century to take only 400 cusecs; thereafter, it was enlarged to take 800 and subsequently 1,100 cusecs, and with the increased demand for canal water in the thirsty districts of Muttra and Agra it has been found necessary to pass down even larger supplies. The branch has now been redesigned and widened to take the increased supplies, and it is expected that the complaints of seepage will in a short time become very much less if they do not cease altogether.

The Committee acknowledge with thanks the replies furnished by the Agriculture Departments of various provinces and the Mysore State to the Questionnaire that was issued by it.

The following is the summary of the steps so far taken in other parts of India for the reclamation of *usar*. These, read with the work done in this province as detailed in the introductory chapter will constitute a suitable background for the Committee to present their recommendations on the subject.

(i) *Sind—Department of Agriculture*

Of all the methods tested at the Agricultural Research Station, Sakrand, the one that has given the most promising result is that of leaching. The method consists in flooding the land with water and washing down the injurious soluble salts to lower layers and then keeping the land under cultivation. The majority of the soils are fairly permeable and therefore leaching can be thoroughly done. The exact quantities of water in different doses have been decided upon as a result of experimentation and the results have been satisfactory. Food and fodder crops are grown on these reclaimed land and the rotation worked out. The main consideration in fixing a rotation for these freshly reclaimed lands should be the reduction of fallow. Crops are grown both in *kharif* and *rabi*, and during the small period of fallow, following the picking of cotton, the land is kept well cultivated. Absence of this precaution leads to the rise of salts to the surface. The Department have no information regarding the planting of trees for fuel and timber on the freshly reclaimed land.

(ii) *Punjab—Department of Irrigation*

In the Punjab as most of the salt areas occur in canal-irrigated tracts and exist in between cultivated lands, their reclamation is always taken up with the idea of growing food or fodder crops. The growing of grasses and planting of trees for fuel and timber do not lead to an immediate return, and therefore from the point of view of the zamindar they are not considered in reclamation projects.

For the purpose of reclamation on economical lines a scientific definition of salt and alkali soils as applicable to the Punjab conditions has been framed. On the basis of this definition soils have been classified into five distinct types.

Type 1.—Soils having a pH value between 7·0 and 8·5 and a salt content of not more than 0·2 per cent. This type is directly cultivable and is capable of giving normal yields of crops.

Type 2.—Soils having a pH value below 9·0 and a salt content of about 0·2 per cent. Such soils are fit for rice only in the initial stages, but with a suitable system of cropping can be built up to type No. 1.

Type 3.—Soils having a pH value between 9·0 and 9·5 and a salt content 0·2 to 0·5 per cent. These soils require leaching and two

or more than two rice crops to be grown before they give normal yields of rice. After rice with a suitable system of cropping they can be built up to type No. 1.

Type 4—Soils having a pH value less than 9·0 but a salt content of 0·5 per cent. or above. These soils are *thur* soils and are economically reclaimable by more or less the same methods adopted for type 3.

Type 5—Soils having a pH value above 9·5 and a high or low salt content. These soils are what are locally known as *rakkar* soils. They are very expensive and very difficult to reclaim. At the present prices of agricultural produce, their reclamation is not advised.

(iii) *Bihar—Department of Agriculture*

No detailed information is available, excepting that the washing out of the salts by irrigation and proper drainage, and the subsequent addition of gypsum or heavy dose of organic matter are found to be generally useful for the reclamation of the type of alkali soils usually occurring in that province.

(iv) *Bombay Presidency—Department of Agriculture*

Excepting in the worst kind of alkali soils, certain amount of food and fodder crops can always be raised with a light irrigation although the yields are always lower than those of good fertile lands. Thus food crops like sugarcane, *jowar* (*Andropogon sorghum*), wheat, rice, gram, etc., or fodders like *berseem* (*Tripolium alexandrinum*), lucerne, *sherri* (*Sesbania aegyptiaca*), etc. can be grown with advantage in these soils, with gradual subsequent improvement in the soil condition. In very bad soils *babul* (*Acacia arabica*) has been found to thrive well.

(v) *Madras—Department of Agriculture*

Departmental guidance, the supply of soil amendments and green leaf manures at low cost and the remission of water-rate during the reclamation period are considered to be the most important steps that should be taken for making the infertile areas fit for cultivation. Attention is also paid to the growing of food crops where irrigation facilities exist. In lands less favourably situated, the possibilities of raising salt-resistant fodder crops and grasses, and planting trees for fuel and timber are to be considered. It is evident that in Madras certain types of alkali land can be progressively made fit for cultivation by leaching or impounding water in embanked fields so as to wash off the injurious salts followed by growing of rice and then introducing some suitable crop rotation.

Mr. Rama Reddi, Director of Agriculture, Madras, writes further on the subject as follows :

An attempt at reclamation of large tracts of alkaline lands was made only recently. I am, therefore, unable to supply detailed information on the points raised.

'In the Kattalai High Level Channel area in which the experiments were carried out, paddy and plantains with green manure rotations are the principal crops raised. With an abundant supply of irrigation water it was possible to flood the land frequently with a view to wash out the injurious salts. The choice had therefore to be restricted to crops that could stand waterlogging. The land is at present in a state of partial reclamation, paddy and *dhaincha* (*Sesbania aculeata*) being the only crops that have so far been tried. As stated in the previous note, the paddy crop came up well in the treated plots, and gave almost the normal yield for the area during that season. Once reclamation is complete, it should be possible to raise any crop that would suit the local conditions.'

There is considerable literature on the subject of reclamation of alkali and *reh* encrusted alkali lands in the United States of America. Some of the methods, both mechanical and chemical advocated for the reclamation of *usar*, are undoubtedly of considerable interest to the agronomist of this province.

Reclamation of alkali lands as practised in the United State of America

The methods suggested for temporary reclamation of alkali lands are as follows :

- (a) Ploughing alkali surface crusts deeply into the soil.
- (b) Removing surface accumulation from the soil.
- (c) Neutralising the effect of certain salts by use of other salts or acids.

For permanent reclamation the following methods are generally advocated :

- (a) Adequate lowering of water-table
- (b) Washing excess salts out of the soil.
- (c) Assuring sufficiently rapid drainage after heavy storms and after the application of irrigation water.
- (d) Careful management of reclaimed land.

The work done at Idaho Agriculture Experiment Station is of special interest. Here experiments are being conducted on 55 acres of exceedingly black alkali land. Over one hundred experiments are being carried out, which include application of various chemicals, blasting, subsoiling, supplementary drainage, straw and manure coverings,

leaching under various methods of irrigation, surface washing, cultivation, and the planting of various crops. Also it is planned to pump and use for irrigation the ground water which has been found to contain considerable calcium. So far the application of chemicals has failed to show as pronounced a benefit as elsewhere. A condition has been found which may explain the failure or slowness of the chemicals to react. Owing to the presence of a dispersed, impervious soils layer 18 in. to 2 ft. below the ground surface, a perched ground-water-table appears following irrigation which persists for several weeks at a time. The impervious stratum is too far from the surface to be readily affected by surface treatments and blasting and subsoiling have proved of no avail. Shallow drainage trenches spaced at frequent intervals appear to be the only method of relieving the situation, though in this instance the calcium sulphate and sulphur applied might very well have reacted to form sodium sulphate. The continued presence of sodium in this form, due to poor drainage conditions, might eventually result in reversing the reaction and again forming sodium carbonate and sodium zeolite. It is possible that chemical treatments together with surface drainage might yet result in reclamation of the tract.

A certain amount of success is claimed to have been attained by Dr. S. S. Nehru, Collector of Mainpuri, within the last two years in the reclamation of *usar* soils by electrocultural treatments. His work has been confined to certain small areas in the middle Doab, notably, Mainpuri and Etah Districts. The method mostly consists of irrigating the plots with electrically sparked water. Except that this treatment has been found successful in a general way, it has not been possible to get from Dr. Nehru either details of the technique, the exact localities where the trials were made, the condition of the land before and after the treatment or the crops raised after the soil was reclaimed. In spite of repeated requests made to Dr. Nehru by the Chairman to put up to the Committee detailed statement covering all or some of these points, it has not so far been possible for the Committee to obtain any quantitative data on the subject. The Committee are, therefore, unable to make any comments on the usefulness or otherwise of this electrocultural treatment. The Committee would be most interested to find if electroculture could possibly have any effect on changing the texture of the soil, i.e., making it more permeable, or improving the micro-biological activities of the soil leading to nitrogen fixation. But no information is forthcoming either from Dr. Nehru or Sardar Surjan Singh to whom the Committee were referred by Dr. Nehru for obtaining further information on the subject.

The present Agricultural Chemist has now obtained definite indications from field experiments conducted on the Government Farm, Unao, that gypsum at the rate of 3 tons per acre is capable of reclaiming *usar* of a refractory type. He has also now been able to show as a result

of laboratory and pot-culture experiments that sulphate of ammonia either singly (6 cwt. per acre) or combined with compost (sulphate of ammonia 3 cwt. and compost 200 maunds. per acre) may prove effective in reclaiming predominantly alkali soils. This, however, has not yet been confirmed on a field scale, but experiments will soon be laid out on a typical *usar* patch at Unao on modern statistical lines to test the validity of these treatments.

Reclamation by the use of sulphur has been carried out with success on some small patches of alkaline and saline lands both in the Madras Presidency and Bombay-Deccan. The success of this method depends to a considerable extent on the oxidation of sulphur in the soil through micro-biological activities and the formation of sulphuric acid which reacts with the sodium carbonate present in the soil.

According to Rao Bahadur Viswanath, Imperial Agricultural Chemist, iron sulphate and alum are good coagulants to work with bad soils. These chemicals become acidic on hydrolysis and bring calcium into solution besides themselves producing marked coagulation. When the soil dries out, the hydroxides produced by hydrolysis are dehydrated, becoming relatively inert constituents of the soil. They also encourage permeability of the soil. The obvious drawback of using chemical correctives for the large-scale reclamation of *usar* soils is the cost involved in securing the chemicals.

At present gypsum is not economically available in the United Provinces. Very recently a private firm, "The Himalaya Mineral Co.", have started supplying gypsum rock from the neighbourhood of Rikhikesh, district Saharanpur. This forms the only source of gypsum in the United Provinces. The price charged by the firm is about annas eight per maund uncrushed rock, f. o. r. Rikhikesh. At this rate the total cost of 3 tons (sufficient for one acre) of ground gypsum at the cultivator's field comes to about Rs.70, inclusive of transport and grinding charges. On the other hand, there is scarcely any difficulty in using gypsum on a large scale in the Punjab. Gypsum supplies there are readily available from the Khewra mines and can be had at about Rs.11 per ton f. o. r., say, Chakanwali or Renala where large-scale reclamation trials are in progress. The North-Western Railway also allows a preferential rate of freight for gypsum to be used for agricultural purposes. If the other railways concerned also agree to a substantial reduction in the freight rates of gypsum for stations in the United Provinces, then it may be possible to arrange for adequate supplies of it at a reasonably cheap rate from Khewra for the reclamation of the large areas of alkali land scattered in the different parts of this province.

The present price of sulphate of ammonia is about Rs.112 per ton f. o. r. Calcutta. At this rate the total cost of 6 cwt. (required for one acre) of sulphate of ammonia works out on an average to Rs.50

approximately at the cultivator's field, inclusive of freight and the other transport charges.

The use of sulphur is at present a very difficult proposition. It is very expensive and there will be administrative difficulties in making it available to the cultivator.

Iron sulphate and alum are also not very cheaply available. Hence, their use on a large scale cannot be advocated on economic grounds.

According to Mr. W. P. Kelly in the United States of America gypsum, sulphur, iron sulphate and alum are found to produce beneficial effect on black alkali soils, but at different rates. These materials act on the soluble carbonate and the clay constituents simultaneously. Gypsum brings about these changes because of its soluble calcium, while the effect of sulphur, iron sulphate and alum is due to their acidic nature, in consequence of which soluble carbonate is decomposed and calcium minerals of the soil, specially calcium carbonate, are dissolved. The calcium thus brought into solution reacts with the clay constituents. Iron sulphate and alum react with the soil most quickly because of their high solubility and acidic nature. Sulphur acts most slowly for the reason that this material must undergo oxidation before it can produce any important effect on the soil.

Gypsum produces uniformly successful results on this soil only when applied at the rate of *more than 10 tons per acre*.

Field experiments at the Kearney Vineyard have shown that the crop-producing power of the Fresno black-alkali soil can be greatly improved by the use of gypsum, sulphur, iron sulphate or alum, provided these materials are applied in sufficient amounts. Yields of alfalfa ranging from 6 to 11 tons per acre per annum have been produced on land which at the beginning of the experiments was entirely unproductive.

The unproductivity of this soil is due to (a) an excess of soluble salts, especially sodium carbonate, and (b) the abnormal chemical composition of the clay-like constituents of the soil.

Small-scale experiments carried out by the Agricultural Chemist to Government, United Provinces, some years ago showed that molasses had a definite ameliorative effect upon *usar* soil from the Cawnpore District. More detailed work upon this is being conducted by Dr. N. R. Dhar in co-operation with the Department of Agriculture, United Provinces. Dr. Dhar is also independently carrying on extensive researches on this subject aided by grants from the United Provinces Government as well as the Imperial Council of Agricultural Research.

During Dr. Dhar's absence from India on leave in 1937 a field experiment on systematic lines was laid out during the *kharif* of that year by the Agricultural Chemist at the Government Model Farm,

Unao, to study the effect of applying molasses to *usar* land on the out-turn of rice. The soil which is typically *usar*, having pH value 9.3—9.6, was treated three weeks before transplantation of paddy with molasses at the rate of (i) 5 tons (ii) 10 tons and (iii) 15 tons per acre. Two more treatments, one control and the other pressmud at the rate of 5 tons per acre, were also included. All the five treatments were laid out in four randomised blocks, the area of each sub-plot being 1/40th acre. The yield figures were statistically treated both in regard to grain and straw. The main conclusions are as follows :

Grain.—(i) Molasses at 10 tons per acre gives the highest yield of grain and (ii) there are no significant differences among the grain yields obtained with 5 or 15 tons molasses, 5 tons pressmud and the control.

Straw.—(i) Molasses at 15 tons per acre gives the highest yield of straw and molasses at 10 tons comes next (ii) There is no significant difference in the straw yields between 5 tons molasses and the 5 tons pressmud treatments ; but either of these is superior to control which shows the poorest lead.

The ameliorative effect of molasses on *usar* soils is undoubtedly indicated by the results obtained from systematic trials hitherto carried out in the United Provinces ; but the high cost of the treatment and the difficulty of transporting and applying it react somewhat adversely against the successful utilization of molasses for reclaiming *usar* lands. In order to minimize the cost of the molasses treatment Dr. Dhar is now actively engaged in trying out mixtures of molasses and pressmud in varying proportions. The results already obtained are promising and it seems that it may be possible to effect reclamation by this process at much lower cost than by using molasses alone.

The data of the field trials conducted by Dr. Dhar during the *kharif* and *rabi* of 1938–39 on an *usar* patch at Soraon, district Allahabad, are as follows :

Field no.	Area under cultivation	Ingredients added	Yield of rice crop (<i>kharif</i>)		Yield of barley crop (<i>rabi</i>)	
			Straw	Grain	Straw	Grain.
	Acres		Srs.	Srs.	Srs.	Srs.
1	0.5	Control—(no pressmud or molasses)..	45	21	6½	9½
2	0.5	5 tons pressmud and 5 tons molasses	290	151½	74	106
3	0.5	10 tons molasses	140	56	70	99
4	0.5	5 tons molasses	180	53	53	80
5	0.5	Control (no pressmud or molasses) ..	5	1½	6	..

Field no.	Area under cultivation	Ingredients added	Yield of rice crop (<i>charif</i>)		Yield of barley crop (<i>rabi</i>)	
			Straw	Grain	Straw	Grain
6	0.5 Acre	5 tons pressmud and 5 tons molasses	270	126	60	91
7	0.5	10 tons molasses	160	110	72	108
8	0.5	5 tons molasses	230	132	56	80
9	0.5	Control (no pressmud or molasses) ..	55	24½	9½	13½
10	0.5	5 tons molasses	160	45	40	52
11	0.27	5 tons molasses and 5 tons pressmud	189	62	43	60

Total yield of grain in molassed fields (area 3.73 acres).

Rice (Paddy)

Straw 40 maunds and 29 seers.

Grain 18 maunds and 6 seers.

Average per acre

Straw 10 maunds and 23 seers.

Grain 4 maunds and 35 seers.

Yield on control plot per acre

Straw 1 maund and 30 seers.

Grain 31 seers.

Barley

Straw 11 maunds and 30 seers.

Grain 16 maunds and 36 seers.

Average per acre

Straw 3 maunds and 5 seers.

Grain 4 maunds and 20 seers.

Yield on control plot per acre

Straw 15 seers.

Grain 14½ seers.

The average yield in good land in the vicinity is about 5 maunds of paddy per acre and 6 maunds of barley per acre.

The views expressed by Dr. Dhar himself on these experiments are given below :

'We are hoping that without any further addition of molasses we shall be able to get a good crop of rice and barley in the next season as we claim that *usar* land has been permanently reclaimed. The small yield in the control plot in the experiment

detailed above is mainly due to some slight quantity of molasses coming in there as a result of heavy rains.'

During the past year or two the Forest Department have been conducting trials on the use of molasses on *usar* lands for growing trees. The following report on these experiments is now available from that Department :

'Two experiments on about $\frac{1}{4}$ -acre each were carried out in the Afforestation Division on the canal banks—in one case the plot was dug 1 foot deep and treated with 120 maunds of molasses per acre and in the other case 2 feet deep pits were treated with sufficient molasses. The first plot was sown with *babul*, *khair*, *siris*, *jamun*, etc., and the second planted with *sissu*, *jamun*, *mango* and *neem*. The sowing and plants started well but the sowings all died. The transplants are still alive but do not appear healthy. It can safely be said that the effect of molasses is only superficial and that the *kankar* pan in *usar* areas does not generally allow tree growth except in scattered bits where the *kankar* is naturally broken or interrupted.'

The Forest Department have, however, now volunteered to undertake systematic experiments in collaboration with Dr. Dhar to test further the utility of molasses and pressmud for reclaiming *usar* soils for afforestation purposes. The results of these trials are awaited.

The observations of the other provinces and States in India on the use of molasses in reclaiming *usar* soil are summarized below :

(I) *Punjab—(a) Agriculture Department*—A series of trials to study the effect of molasses as a reclaiming agent for alkali soils (*bari*) was started at Montgomery in 1936. One year's results are available and it is evident that molasses at 50 or 100 maunds per acre brings about a very marked improvement in the yield. The cost of molasses at Montgomery is 12 annas per maund, and at this value according to the Agricultural Chemist, Punjab 'It is extremely doubtful if the reclamation of the *bari* type of alkali soils will be an economic proposition'.

He finds some other methods of reclamation more promising and useful.

(b) *Irrigation Department*—Experiments were carried out in the laboratory to see how far molasses was superior as a reclaiming agent to gypsum, and a comparative study of the effect of increasing amount of molasses and gypsum on pH, exchangeable calcium and dispersion factor of a soil of high alkalinity was also made.

The pH of the soil treated in the laboratory was about 9.5 and the salt content was 0.3 per cent.

Molasses and gypsum were added in quantities varying from 0.2 to 2.0 per cent. of the weight of the soil.

The laboratory experiments were carried on for one-and-a-half months. These experiments showed that the addition of molasses to the soil did not bring about any change of a permanent character in the degree of alkalization or the physical texture of the soil. Field experiments were carried out for only one season on a soil having a pH value of about 9.5. The results were negative, i.e., the molasses and pressmud, treated plots were not better than those that were untreated. Also the cost of the material together with their cartage to the field is considered to make the use of molasses and pressmud somewhat prohibitive.

(II) *Bihar—Department of Agriculture*—Both from laboratory and field experiments the indications are that molasses may prove to be of great assistance in reclaiming alkaline soils.

(III) *Mysore State—Bio-chemical Section*—For about the last two years the bio-chemist in charge of experiments has been carrying out investigation on the reclamation of alkaline lands by molasses. It should be noted, however, that these trials being purely qualitative and largely of an exploratory character, the results obtained therefrom are of very limited value.

The nature of the alkali lands where the experiments have been tried so far appear to be predominantly 'saline.' The quantity of molasses applied varied from 2 to 3 tons per acre, and in a few cases two applications of molasses in successive years were made. The alkalinity of the soil varied from pH 7.5 to pH 9.0 and only very rarely was pH 10.0 noticed.

Treatment with molasses of mildly alkaline land (pH 7.5 to 8) gave a grain yield of 2,200—3,300 lb. in the first year, but subsequently the yields dropped down to 1,200—1,600 lb. in the second and third year. The highly alkaline lands (pH about 9), on the other hand, gave comparatively low yields of about 400 lb. per acre, though drainage and other facilities were provided.

In one case, on about 4 acres, a green manure crop of sunnhemp was taken two months after the application of molasses and ploughed in when that crop was about two months old. Paddy was then taken and gave a grain yield of 2,000 lb. per acre against a check yield of 3,400 lb. In the subsequent two years, an average crop of 1,100 lb. per acre was obtained.

It is difficult to give an exact account of the cost of these treatments as the supply of molasses was obtained free. As regards the cost of cultivation, it was, however, to the extent of 3 or 4 more ploughings in the treated plots than in the untreated one. The treated area that could conveniently be ploughed in a day by a pair of bullocks was very nearly half of that of untreated land—thus doubling the cost of both

labour and animals required for every ploughing. Moreover, the extreme discomfort that both man and beast feel in working on a molassed field, specially in the earlier period, often adds to the slowness of the work.

The Mysore Department of Agriculture are of opinion that the use of molasses in its present form is only possible within a limited distance from source; that the method of its application should be so modified as to minimize discomfort to both man and beast, and that means should be found to minimize the time-lag that must occur before any cropping can be done on land where molasses has been applied.

Preliminary trials on ryots' land were hardly satisfactory. Ryots were not agreeable to continue these trials due to, no doubt, some of the limiting factors mentioned above.

Certain pot-culture and statistical field trials are being carried out; but have not yet yielded any significant result.

It will thus be seen that the trials conducted in Mysore are yet in a very preliminary stage and do not warrant an authoritative opinion on the practical application of molasses to alkaline land for reclamation purposes, whatever may be the theoretical possibility of such a process.

(IV) *Madras Presidency—Department of Agriculture*—Field trials have only been started on an alkali patch (pH value about 9·7) on the Central Farm, Coimbatore. The Agricultural Chemist, Madras, is, however, of opinion that molasses unless applied in very heavy doses is not suitable for the reclamation of alkali soil. Applied at the rate of 8 tons per acre in the field it brought about only a very slight fall (about 0·2) in pH in the course of a month. No data regarding crop yields arising out of field trials are as yet available.

(V) *Sind*—No information is available as the Department of Agriculture there never undertook any experiment on the use of molasses for reclaiming saline soils.

(VI) *The Imperial Agricultural Chemist, New Delhi*, although he never conducted specific field experiments on the use of molasses in the reclamation of alkaline soils, is of opinion from observational results that molasses would do very well as a corrective for alkaline lands which are not too alkaline. In regard to the worst land, he is, however, of opinion that the application of molasses may be a temporary palliative, if of any use at all. Molasses may bring about a slight improvement, but it will only be temporary and superficial even if the reaction products are removed by drainage.

(VII) *Bombay Presidency—Department of Agriculture*—Molasses has had some effect at the Padegaon Sugarcane Experimental Station in the reclamation of the so-called *chopan* (hard-clay) soil but the process is considered slower than the reclamation carried out with sulphur combined with farmyard manure.

The views expressed by Dr. Dhar on the mode of action of molasses in *usar* soils are summarized below.

Molasses contains between 60 to 70 per cent. of carbo-hydrate, 4 to 5 per cent. potash, 2 per cent. lime, 0.5 per cent. sulphuric acid, 0.5 per cent. iron and aluminium oxide and 0.5 per cent. combined nitrogen and the rest water. When molasses is added to the soil, along with carbonic acid, organic acids, like acetic, propionic, butyric, lactic, etc., are produced in the early stages by the decomposition and partial oxidation of the carbo-hydrates present in molasses. Moreover, molasses by itself is definitely acidic. Consequently, the acids present in molasses and those obtained from its decomposition and partial oxidation can neutralise the alkali of the soil, and the carbonic acid which is produced in a large quantity from the decomposition and oxidation of the carbo-hydrates can convert the sodium carbonate into bicarbonate. Also in the process of the escape of carbonic acid from the molassed soil the latter is rendered porous and its tilth improved.

The lime which is added to the soil along with the molasses is rendered soluble by the organic acids formed from molasses and is helpful in the conversion of the sodium soil into a calcium one, that is, normal soil.

The soluble calcium salts are beneficial in the improvement of the soil tilth by their flocculating power on the clay particles. In the presence of soluble calcium salts the permeability of the soil is greatly improved. Moreover, the carbo-hydrate material present in molasses encourages the growth of nitrogen-fixing bacteria like *Azotobacter* in the soil which is thus eventually made richer in total nitrogen. *Usar* soils, as a rule, contain much less total nitrogen (0.008 to 0.02 per cent.) as compared with that in the normal soils in which the nitrogen content ranges between 0.04 per cent. and 0.1 per cent.

As is well known, apart from the intrinsic merit of any fertilizer, the cost at which it is available to the cultivator makes all the difference between its ultimate success and failure. It is, therefore, a matter of first and foremost importance to consider whether the total cost involved in the molasses treatment would be commensurate in all cases with the increased gain in the shape of land improvement on a permanent basis and added outturn of crop yield. So far as our experience goes, the price of molasses fluctuates very much from year to year. In the past two or three years it has been possible to secure a supply of molasses, for instance, at 4 or 5 annas per maund at Cawnpore. Even at four annas a maund the price of 10 tons of molasses, ex-factory, works out to about Rs.70. Add to this the cost of transport which is at least Re.1 per ton for a distance of about 10 miles from the factory, the total cost of 10 tons of molasses, meeting the

requirements for only one acre, works out under the most economical conditions to about Rs.80. If, on the other hand, molasses is to be transported by rail to stations far away from the factory, then the freight charges and the cost of better types of containers will add considerably to the total cost of the treatment ; that is, the price of molasses at the cultivator's field in that case will not be less than Rs.100. In all probability, it will perhaps stand at a higher figure. Of course, if the reclamation is organized on a large scale, it may be possible to induce the railways concerned to arrange for special wagon containers, which will reduce the cost considerably on account of the elimination of the iron drums which are at present used. With a mixture of pressmud and molasses the cost of treatment will naturally decrease.

The consensus of opinion of the majority of members is that an ordinary cultivator is likely to find the cost of the treatment to be prohibitive. Moreover, it appears somewhat difficult to recommend this method for places situated at a greater distance than 10 or 15 miles from a sugar factory. Further, the Committee must take into consideration the recommendation of the Power Alcohol Committee which has definitely recommended that one-tenth of the total supply of molasses available will be utilized for the manufacture of power alcohol. Other industrial uses of molasses may be found and one cannot lose sight of the fact that in future the price factor on account of increased demand in other directions may not prove an inhibitive factor.

Further, the Committee are, on the data at present available, unable to recommend with confidence the value of the molasses treatment in general owing partly to lack of critical data on the following points :

(i) results from field experiments carried out on modern statistical lines. At present most of the available data from field experiments are not capable of statistical interpretation ;

(ii) the physical texture and chemical composition at different depths of the soils reported to have been reclaimed both before and after treatment ; and

(iii) the permanence and continuance of the improvement.

Dr. Dhar has already been granted Rs.5,000 by the United Provinces Government for carrying on large-scale field experiments on the reclamation of *usar* by molasses in different parts of the United Provinces. A similar grant has also been sanctioned by the Imperial Council of Agricultural Research to enable him to undertake further experimentation and research on the subject. The Committee are, therefore, definitely of opinion that the results of these experiments, including the trials to be shortly started by the Forest Department, should be awaited and every facility given to Dr. Dhar in the selection of areas near sugar factories for plot demonstration of the ameliorative character of molasses.

From what has been detailed above, it will be evident that attention in this province has so far been concentrated on the reclamation of only the more hopeful type of alkali soils, i.e., those soils which have not undergone structural degradation to the extent of making plant growth impossible. There are various phases of degradation to which the soil is liable in regard to alkali formation. There are some soils which constitute the first stage of degeneration, i.e., where calcium in the clay-complex has not been displaced to such an extent by sodium as to make the soil not amenable to simple methods of reclamation. There are others in which this change in the clay-complex has proceeded to such an extent that reclamation methods more elaborate and prolonged than those required for the first type of soil will obviously be necessary. Lastly, extreme cases of soil alkalinity would mean a complete replacement of calcium in the clay-complex by sodium. The reclamation of this type of soil, which is by no means uncommon in the United Provinces, would call for very drastic measures, the cost of which appears at the present market value of land to be incommensurate with the advantage gained.

From the analytical results so far available, it appears that the intractability of these soils can be broadly correlated with the pH value as follows:

Group I—mildly alkaline and easily reclaimable—pH 7·6—8·7.

Group II—moderately alkaline and more difficult to reclaim than those in Group I—pH 8·7—9·4.

Group III—markedly alkaline and difficult to reclaim—pH 9·4—10·8.

The Committee support the present policy of the Agriculture, Irrigation and Forest Departments to concentrate attention first on the reclamation of the more mild types of alkali land in the province, i.e., groups I and II mentioned above. The worst types of alkali soils should, in the opinion of the Committee, be marked out for manipulation when the increased pressure on land justifies their reclamation and the price factor has risen so high as to make their expensive reclamation a paying proposition. All the same, the Committee would deprecate any halt being cried at this stage in the domain of scientific research into the nature of the surface and sub-soils and the pre-disposing conditions leading to alkali formation. To apply ameliorative treatment for the worst type of alkali lands without sufficient knowledge of the conditions to be corrected is to work in the dark and risk a failure. A continual evolution chemical, physical and biological goes on in the soil and, according to Professor A. A. J. de'Sigmond of Budapest, it is this dynamical character of soils that makes the elucidation of reaction of the alkali soils to reclamation measures so difficult. Unless the new treatment of the soil entirely changes the soil dynamics in a way that will lead to a normal

agricultural soil, the reclamation, although possibly temporarily effective, will neither be complete nor permanent. Economically, half measures may sometimes be preferable, *but they will involve a permanent struggle against the natural forces prevailing in the soil itself.* On the other hand, if once we succeed in directing the course of soil evolution and soil dynamics into the required channel, the *natural forces in the reclaimed soil will assist us in bringing our treatment to full success.* Herein lies the practical value of a knowledge of the dynamics of alkali soils, for without it we cannot be sure of the success of our reclamation treatment.

Since the year 1896 experiments have been in progress in the United Provinces to test the possibilities of improving fodder supplies from *usar* plains in the province. At present there is a considerable shortage of fodder supply. On an average, according to a rough estimate made by the Fodder and Grazing Committee, hardly 5 seers of fodder per head of cattle per day are all that is available. It is an unquestioned fact that the lakhs of acres of the so-called *usar* areas in the province constitute the main and probably the only grazing grounds for the cattle, and will continue to be so until methods are perfected for reclaiming *usar* for bearing fodder crops and grasses.

From the Cattle Census Report, 1935, it is seen that the average figure for the grazing incidence for the major part of the province works out to nearly $5\frac{1}{2}$ animals per acre for 20 selected districts and the figures vary from 4 to 7 animals per acre, ignoring sheep, goats, equines and camels. Such intensity of grazing, in the words of Mr. Smythies, 'is almost incredible by world standards even for the best pastures, and is utterly beyond the capacity of the very inferior pastures that *usar* or our waste lands are.' At present there is no attempt to control the grazing in any way whatever, and there is no organization or means to do so. According to European and American standards, even 3 acres of good grazing land per head of cattle are considered to be somewhat inadequate. Moreover, the absence of covering vegetation on the land leads to rapid run-off and erosion in its worst form. The United Provinces Government are evidently alive to the danger, and the draft of the Rural Development Bill foreshadows the setting up of an Authority in each district to take necessary steps for utilizing fully these 'pasture areas' for the purpose for which they were set apart in the village economy.

Considering all these factors the Committee are of opinion that one of the chief uses of the land described as '*usar*' in common parlance and which is capable of being reclaimed should be the raising of fodder so as, to some extent at least, to meet the deficiency in the average food available for cattle.

Experiments made in the past to study production of fodder by the Agriculture Department and recently by the Forest Department at

Juhi, Amarmau, Gursikran and Cherat show that, if the areas are kept free from grazing, the natural grasses would grow more or less luxuriantly and better grasses would establish themselves. The grasses mainly consist of :

- (1) *Khas usara* (*Sporobolus arabicus*).
- (2) *Ursanta* (*Chloris variegata*).
- (3) *Dab* (*Eragrostis cynosuroides*).
- (4) *Dab* (*Cynodon dactylon*).
- (5) *Jargi* (*Andropogon annulatus*).
- (6) *Gandar* (*Andropogon aquarrosus*).

In the year 1931, an experiment was started by the Forest Research Branch, United Provinces, on an *usar* area of 32½ acres at Mukhdoompur at mile 24, Lucknow-Cawnpore Road. The results so far obtained show that protection from grazing during the rains has a very remarkable progressive effect on increasing grass production. This trial which is still continuing clearly demonstrates that, by keeping off cattle, it is possible to increase the yield of grass on such lands. Even with restricted grazing on such enclosed areas a considerable increase in the yield of grass is obtained.

With a view to examine this point further, an experiment was started in the year 1937, by the Department of Agriculture in co-operation with the Forest Department at Amausi at mile 8, Lucknow-Cawnpore Road. The results are not yet available.

In the opinion of some of the members, Kr. Har Prasad Singh, Thakur Manak Singh and Mr. Radha Mohan Singh, this method of bunding up *usar* lands during the monsoon months leads to gradual amelioration of the fields.

The following aspects of this method must, however, be borne in mind before it is adopted on any extensive scale :

(i) In most cases, *usar* soil could be made to grow grass if protection from grazing could be provided during the month of July, August, September and October. But, as indicated by Mr. Richards, such a measure although advisable would deprive the cattle of fresh green fodder which is usually more nutritive on account of a large percentage of proteins and possibly larger amount of vitamins. It is therefore, necessary to work out methods of rotational or 'limited' grazing, which will provide continuous rains grazing combined with sufficient protection to enable the natural grasses to seed and develop and thereby produce more fodder as well as check run-off.

(ii) Restricted or compartmental grazing would obviously require introduction of silos, i.e., more stall-feeding of cattle.

The Committee want to put on record the fact based on the experience of some of its members that where stall-feeding predominates, greater care is exercised in the efforts made to keep the superior cattle above the starvation level ; while, on the other hand, where grazing areas are available but are not properly controlled, very little selection is exercised and, as a result of cattle grazing indiscriminately, many of them remain on starvation diet. It is desirable therefore not only to improve facilities for grazing but to encourage larger areas being made available for growing of fodder crops as a regular item in a scheme of rotation. The point has particular relevance to the terms of reference before the Committee. The Committee are definitely of opinion that as areas are being reclaimed, emphasis must be put on the growing of fodder grasses and crops to a larger extent so as to increase the total quantity of food available for the cattle population and for the exercise of discrimination in the selection of the cattle admitted to grazing on selected pasture areas. The Committee also would emphasise the fact that in order to make the present and prospective supply of cattle food provide optimum nutrition for efficient cattle, the number of cattle the peasants keep must be reduced.

The Forest Department have considerable experience of alkali lands (a) in specified blocks such as Juhi, Abbaspur, Gursikran, and Mukhdoompur and (b) in extensive strips along the 700 miles of canal plantations in the Aligarh, Agra, Etah, Mainpuri, Etawah, Farrukhabad, and Cawnpore Districts.

The following conclusions may be accepted as proved :

(i) Afforestation of alkali lands *as a whole* by tree growth is impossible owing to the presence of *reh* on the surface in the worst type, and to the frequent presence of impermeable strata (commonly *kankar* pans) below ground level. It is possible to afforest pockets of better soil in alkali plains, and an occasional *babul* or *nim* or *dhak* tree will struggle up to a stunted condition here and there, but complete and vigorous tree growth all over alkali lands is definitely not possible, except perhaps by such quite uneconomic methods as the use of dynamite or high explosive.

(ii) On all alkali soils, except the worst type of *reh*, control of grazing has a marked effect on the production of grasses. The best results are obtained by complete closure to grazing and substituting grass cutting, but this is not a practical proposition. Very fair results are obtained both by closure during the rains and subsequent unrestricted grazing, or by rotational blocks, with limited grazing. With any of these alternatives, the natural vegetation, i.e., a thick growth of grasses, is enabled to develop during the rains, and a thick grass crop is now recognized as being practically as efficient as tree growth in checking run-off and erosion on flat lands.

(iii) The increased growth of grasses following control of grazing naturally means more fodder production. The protection tends slowly to bring in the better fodder grasses such as *dub*, *anjan*, *musel*, etc.

In the immediate vicinity of large towns, where the demand for grazing is enormous, the control of grazing in alkali lands and the consequent stocking of the area with grass are clearly indicated. Thus the Juhi block near Cawnpore, which was originally acquired for Rs.900 has been paying an average of Rs.900 per annum for the last ten years. But, on the other hand, areas far away from big towns, such as Mukhdoompur area, do not pay, since the villagers are not accustomed, and are at present not prepared, to pay for grazing. In such areas it is necessary to convince the villagers that it is to their interest to close waste alkali land during the rains for rotational grazing so as to maximise fodder production during and after the rains.

The Committee had before them the complete report of what is being done by the technical departments of other Governments in the direction of reclamation of *usar* areas. This has already been outlined above. The Committee would, however, wish to indicate that they feel that the measures of an ameliorative character which were recommended in a more or less empirical manner in the past do still retain the field, and, when applied under systematic control, yield good results. What we would concentrate our attention on now would be (i) co-ordinated effort between various departments and (ii) improvement in organization which would translate into practice the directions of the technical departments and to bring a scientific perspective to bear on the scrutiny of the problem of land conservation in general and *usar* recamation-in particular. The Committee wish to further emphasise that the main objective should be not to aim at achieving temporary results but to get at the bottom of the quintessentials of the problem of soil deterioration, keeping in view all along the modern conception of the dynamical character of the soil. Incidentally this would necessitate classification of soils. The Committee want to make it clear that *usar* land should be reclaimed, irrespective of the fact whether it bears food crops or fodder or trees only.

They feel that the problem of reclamation of *usar* cannot be divorced from the problem of pasture lands; and reclamation of *usar* in the main would resolve itself into setting up of a balance between the cultivated area and the area put under grasses and trees.

The Committee cannot lose sight of the fact that out of the area of 21 lakhs of *usar* and *reh*-encrusted *usar* so far reported by the Land Records Department, 50 per cent. is included in the Civil Divisions of Agra and Allahabad. The Chief Irrigation Engineer made it definitely clear that,

except in the rains when for technical reasons they do not consider running of the canal advisable, no water can be spared from the irrigation of cultivated land. As a matter of fact, every drop of water available could, in his opinion, be more profitably utilized in irrigating more cultivated land than diverting it for purposes of reclamation. The solution, therefore, lies in making use of rain-water and impounding rain-water by setting up field *bundhis* on contour lines. Wherever this is done and green manure in the form of *sanai* or farmyard manure or compost have been applied, mild *usar* has responded to the efforts of the cultivator and produced a crop. In the area commanded by the Sarda Canal, however, the prospects are slightly better, surplus water being available for leaching alkali soils of their deleterious salts. The Irrigation and Agriculture Departments have combined their efforts in demonstrating to the agriculturists how *usar* areas should be reclaimed for cultivation wherever water from the Sarda Canal is available. On a rough estimate, it may be assumed that water would be available during *kharif* for reclamation of *usar* areas in non-sugar tracts for some 15,000 to 20,000 acres for about a period of 15 years and these in time would become rice areas. The method consists of alternate flooding and cultivation of the areas with a run-off for the surplus water. This is done in the months of April and May. If the land permits, a crop of sunn-hemp (*Sanai-Crotalaria juncea*) is planted and used as green manure followed by early paddy. Paddy type 21 has been found to do well in most cases, and types 23 and 17 where the land is more markedly alkaline. By this process, it has been found possible to obtain a fair crop of paddy in the very first year. In some cases it has been followed by a *rabi* crop under irrigation the same year. The process is repeated the following year and the land shows marked improvement. There are large numbers of zamindars and cultivators now who find it profitable to reclaim waste land by this simple method.

This method or reclamation has been the subject of grants-in-aid from the Board of Agriculture and by the Director of Agriculture. Thus the Unao Farm and the Bara Banki Model Farm were located in *usar* tracts, with a considerable portion of *usar* soil within their boundaries, for demonstration of the possibilities of such ameliorative measures. The Unao Farm has shown that mild *usar* soil can be reclaimed for profitable growth of rice and other crops by leaching combined with organic manuring, the application of sugar factory pressmud cake or dressing of town sweepings or *nala-silt*. On the Cawnpore Research Farm mild *usar* has been reclaimed without heavy leaching by cultural methods, including the growth of deep-rooted legumes, green manuring or trenching with *juar* and sugarcane roots, and by manuring with large doses of compost combined with good cultivation. The demonstration of the efficiency of leaching combined with green manuring on mild *usar* has been so impressive that

the Irrigation Department are providing free irrigation water up to the surplus supply available for reclamation in this way.

The Committee recommend that, as proposed by Professor Singh, the criterion in future for irrigation requirements be determined on the basis of the water-requirements of the crop and the character of the soil. In order to ensure this the Committee recommend the minimum supply of irrigation water on the recommendations of an officer of the Central or the District Waste Land Reclamation Board in order to conserve canal water for reclaiming *usar* land and avoiding the formation of fresh *usar* land due to excessive irrigation.

An area in village Panchali, district Meerut, was put at the disposal of the Forest Department by Khan Bahadur Sheikh Wahid Uddin Sahib, C.I.E., for plantation of trees. The plantation was carried out on the approved methods of the Forest Department; but the trees did not flourish except where they found by actual examination that they were planted in pockets of good soil. No doubt the Forest Department is a commercial department and is, therefore, not in a position to spend money on experiments likely to prove financial failures; but from the experience so far gained they claim that in mild *usar* and in extensive areas lying uncultivated as *usar*, wherein pockets of good soil occur, the departmental efforts for afforestation have succeeded. The reasons are obvious. It is the impenetrability of the stiff clayey soil or *kankar* pan that has been responsible for the inhibition of the growth of tree planted by the Forest Department at Panchali. The Committee would like to observe that, if the experiment is carried out by a village organization where the question of payment of labour does not assume a prominent place, it may be possible on that type of *usar*, as the historical portion must have shown, to plant trees, provided that the *thala* that is prepared is a deep one, extending beyond the hard pan or the impenetrable clay and opening out into the coarser soil.

In the United Provinces we have not got purely saline type of *usar*, excepting in patches near canals. Wherever it occurs it is mostly explained by some sort of defect in the alignment of the canal or insufficient provision for drainage. Reclamation of purely saline areas is easy. The original cause which brought about a rise in the water-table and of salts to the surface is to be removed, and the Canal Department has systematically taken steps to remove the defects. The photograph given in Appendix IV (a) shows a typical patch of waterlogged land adjoining the Hathras Branch in the Iglas Tahsil of Aligarh. This site which was inspected by the Chairman and the Secretary was till 4 or 5 years ago under cultivation, but has now been rendered useless due to waterlogging through excessive seepage from the canal. The Waste Land Reclamation Board have to see whether these defects are completely removed by providing for drainage cuts

and, in the case of land in which the spring-level is not too near the surface and the sub-soil is somewhat sandy, supply of water is arranged without charging water-rate to supplement any scheme of impounding rain-water for purposes of leaching out all the injurious salts. Technical advice will always be available for sowing of leguminous crops for increasing the organic matter content of the soil and also providing the necessary amount of nitrogen necessary for procuring a healthy soil.

According to Messrs. James Thorp and C. S. Schofield poor drainage in the arid regions commonly leads to the accumulation of soluble salts on or near the surface and these salts inhibit or prevent the growth of most crops. Drainage is, therefore, a matter of first and foremost necessity in the reclamation of saline and alkali soils. In any event it is essential that root-zone restriction by sub-soil water be prevented. Movement of water downward and out must be maintained. This is the purpose of drainage. In many instances it will be essential to instal drains to keep the level of ground water below the point where it may be drawn to the surface by capillarity. This depth ranges from 2 to 10 feet, depending on the texture and structure of the soil.

The Chairman made a tour of inspection in tahsil Koil of Aligarh District of saline conditions that had obtained on both sides of the Upper Ganges Canal near Sumera where the head of water was raised by 5 ft. in order to procure a fall for the generation of hydro-electricity. This led to seepage. There are about 10 villages which lie on either side of the canal in this portion. They were already low-lying and *reh*-infested; but the raising of the water-level made them worse. There is evidence to show that *reh* has considerably increased during the past four or five years, that is, after the raising of the level of the canal water, and cultivation and vegetation have been destroyed owing to seepage and waterlogging. *Reh* either appeared over extensive areas rendering uniform tracts unculturable or in patches in the midst of cultivated areas. The Chairman made a detailed inspection of village Bajgarhi which is under the management of the Court of Wards and it shows comparatively greater signs of deterioration. He also saw a portion of that village where an attempt has been made at afforestation by planting *babul* trees. A photograph of this is attached, *vide* Appendix IV (b). *Babul* was planted several years ago as an experimental measure with the advice of the Forest Department, and, although it seems that the place is rather neglected and no further attempt has been made to extend the experiment on scientific lines, it is obvious that the land had improved and is capable of afforestation. Thakur Raj Kumar Singh of Barauli, a local *rais*, who takes interest in the reclamation of *usar* land stated from experience that if *reh* land in this locality was flooded with water and protected from grazing, it grew grasses in three stages. The first stage was long

acicular grass that does not grow high but creeps on the ground. This kind of grass grows copiously after rains but is liable to be destroyed by the hoofs of the animals. The second stage was a long and thin grass, tufted at the top and the third stage was a long thin grass with leaves growing on the stems laterally. The grass never becomes nutritious for the animals ; but, if allowed to stand on the land, adds to its organic content.

We have received complaints from the side of Kapna village, district Bulandshahr, of a similar deterioration due to waterlogging. The salts have come up to the surface as a result of the highly saline sub-soil water forming a column with the surface water accumulating through seepage. Wherever water evaporates, the salt deposit is left on the surface rendering the soil infertile. The Canal Department have started putting down cuts both near Sumera and Kapna. This would serve the double purpose of removing surplus seepage water as well as setting in motion the sub-soil saline water. Evidence from the Punjab indicates that wherever stagnant water has been set aflowing the main defect of absence of aeration is removed and even sugarcane is found flourishing in areas which are practically waterlogged.

The Committee recommend the necessity for a more scientific classification of alkali and *reh*-infested land so that the Waste Land Reclamation Board may be in a position to assess the magnitude of the work and prescribe the appropriate remedies for reclamation.

The following ameliorative measures are suggested :

(a) On plots which are considered hopeful for crop and grass-growth. The Departments of Agriculture and Irrigation combined should make experiments, on the scale of demonstration plots, for trying out agronomical and chemical methods of reclamation of alkali lands. The Committee hope that the question of cost of the methods employed will always be kept in the forefront.

(b) The Forest Department should be given every facility for afforestation of areas which are at present bereft of any trees. The Committee would sound a note of warning that one must not be disappointed if the growth of trees or grass falls short of expectation. The question resolves itself into getting something out of an area which at present is yielding nothing, not to speak of the imperceptible but cumulative ameliorative character of any *vegetation* on these areas. Where the question of cost of planting trees becomes a prohibitive proposition from the point of view of a commercial Government department, the question should be taken up by a local authority with the advice of the Forest Department so that the labour put into the work will be available at the lowest possible rate, if not gratis, and all that would be necessary would be on an agreed basis to give to the planter of the tree certain right of property in the tree.

(c) These level plains should be bunded up into convenient *kiaris* so as to impound as much rain-water as possible and prevent sheet erosion. Every effort is to be made to encourage the growth of natural grasses on these natural *bundhis* so as to provide binding material for loose earth. From the time of Dr. Voelcker experts have emphasised the possibility of alkali areas bearing a fair crop of grass, provided cattle are kept out by a reasonable system of closure during the monsoon months. The Committee lay the greatest emphasis on this aspect of the work. Most of these so-called *usar* areas constitute the pasture lands but which would under ordinary conditions never render the growth of grass a practical proposition.

(d) The Committee had very insufficient material as regards the ameliorative effect of the growth of saltworts on soils with preponderance of deleterious salts. In the introductory chapter are mentioned experiments where the growth of salt-bushes was attempted at Gursikran in the Aligarh District but it failed. It is known to the Chairman that the growth of salt-bushes in the Bikaner State does bring about a reduction of salts in the soil. The plant when burnt yields, up to 15 to 20 per cent of its weight, pure alkali salts. But the soils of Bikaner are more akin to the soils of Sind and, therefore, those salt-bushes may not prove equally efficacious here. Dr. Puri of the Punjab Irrigation Research Institute referred to *khar booti* grown in the Multan and Muzaffargarh Districts, which not only flourish on saline soils but effectively reduce the amount of deleterious salts in the soil and sweeten it. The Forest Department is prepared to build up a nursery and try the experiment of growing these plants on canal banks which have been put under their control in order to find out whether the growing of these plants would bring about an appreciable effect in reducing the amount of harmful salts in the soils.

(e) In areas where canal water is available for leaching of saline we recommend the continuance of the present joint action on the part of the Irrigation and Agriculture Departments to provide free of charge canal water for growing *sanai* in April and May to enable the crop to be ploughed in green in July when the area is to be brought under transplanted paddy type No. 21, and types 23 and 17 when the land is of a markedly refractory nature. Where canal water is not available, every facility is to be given for sinking of wells and setting up of *bundhis* for impounding rain-water so that leaching may be initiated and the cultivation of *sanai* followed by paddy may be rendered possible. We recommend working out of a strain of paddy which would be drought-resistant, e.g., the hill varieties of rice which the Punjab Government have tried with success, or *daneba* grown extensively in Egypt and which Dr. MacKenzie Taylor is recommending.

As will appear in the notes of district work, reclamation of *usar* land has been carried out in a purely empirical style in the following different ways by zamindars and villagers.

In the *usar* tracts of Fyzabad, Jaunpur and Azamgarh Districts, *usar* areas are being reclaimed by the mere process of scraping to a depth of nearly a foot of the top earth which is *reh*-encrusted, putting up an embankment round the field and allowing the rain-water to soak through. Rice is planted next year and though difficulties are sometimes experienced in providing irrigation at the end of the rainy season, tenants combine and effect irrigation by basket-lifts from water which collected in borrow pits. This is a rough and ready method which the Committee wish to commend to the Rural Development Organization. The Raja Sahib of Jaunpur has also scraped extensive areas of *reh*-encrusted *usar* and has put round the scraped land a high embankment to impound all the rain-water. Then he has put clay sods dug out of a tank which receives the drainage of the village. The Manager reported to the Chairman that the farm was doing well.

It has been found that immediately one bores through the bed of the *bajri* or small *kankar* that occurs from $\frac{1}{2}$ foot to 3 feet below the surface and rain-water is allowed to go through, deleterious salts are washed out and if seedlings about a year old are planted in these holes in which fresh earth is put in with leaf-mould, the plants take root and flourish. A fine avenue of trees runs all along the area which is at present *usar*. All that is necessary is to have a simple instrument which could be worked by villagers for boring through the *bajri* or the small *kankar* bed. The Rural Development Officer was prepared to accept this suggestion as he is putting up bore-hole latrines in the countryside and a similar instrument could be worked by villagers for boring holes through the hard pan. Another method is to construct *bundhs* on contour lines wherever there is a slope and capture all the silt that flows down with rain-water and get it spread over the area that once was *usar*. Mr. Bishan Man Singh of Fatehpur has demonstrated how success could be achieved by following this inexpensive method. He planted on this partially reclaimed area *babul*, *ber*, *nim* and *shisham* on the trench and ridge system. The area has reclaimed itself after a certain period and it now contains plots where paddy in certain fields and normal *rabi* crops in other fields are grown. In short, where calcium has not been completely replaced by sodium reclamation has been brought about by bunding up the area and addition of farmyard or other organic manure or accumulated silt.

The question arises what should be the organization set up that would take up the question of reclamation of *usar* and improvement of alkali lands in general. The Committee recommend that a Provincial Waste Land Reclamation Board should be set up at the headquarters of Government, on the analogy of the Waterlogging Board of the Punjab, to grapple with all problems for the reclamation and improvement of waste lands. It should be presided over by one of the members of the Board of Revenue because the Committee would like

to make it clear that the future land revenue of Government is jeopardised if long-range planning is not put in train to prevent deterioration of existing culturable areas ; and, therefore, the Revenue Department is the one most interested in soil conservancy. The other members will be the Chief Conservator of Forests or his nominee incharge of the Plains Afforestation Circle, the creation of which the Committee has later on recommended ; (2) the Irrigation Chief Engineer or his nominee ; (3) the Director of Agriculture or his nominee ; and (4) the Rural Development Officer. There will be thus 4 permanent officials as members of this Board. They could co-opt any head of the technical departments like Co-operative, Settlement or Industries for dealing with specific problems. Among the non-officials will be (1) three nominees of the legislature and (2) two persons selected by Government being *surpanches* of Village Better-Living Societies and two nominated by Government representing landed interests. The Government will nominate three experts one of whom at least shall be selected from the staff of any of the universities of the province. The number including the Chairman should not exceed 15. A whole-time technical Secretary will be associated with the Board. He will be an expert in agricultural matters.

The powers of this Board will be as follows :

- (i) It will formulate the policy of land reclamation.
- (ii) It will suggest how the funds provided by Government are to be utilized.
- (iii) It will, under the various fund-raising provisions of the proposed Act, suggest the raising of funds for meeting expenses in connexion with reclamation of waste areas.
- (iv) It will act as a controlling authority of the district authorities in the matter of carrying out the policy in detail in every district.
- (v) It will be prepared to give advice to district authorities in carrying out any scheme of reclamation or improvement.

The district 'Authority' will be constituted as follows :

- (1) Collector of the district—*exofficio* Chairman.
- (2) Chairman, District Board or any organization to control rural areas that may be set up in its place.
- (3) Two representatives of landed interests appointed by Government.
- (4) Two representatives of tenants' interests, selected preferably from the village organization set up under the contemplated Act or registered or recognized by the Co-operative Department and the Rural Development Organization of the province to represent agricultural interests.

Technical experts of the Departments of Agriculture, Co-operative and Irrigation will be nominated by the respective departments as members of the 'Authority' set up in the district. They will take part in discussion and offer their technical advice but will not vote.

Finance

The Committee feel that a clear distinction must be drawn between works of reclamation which would involve a larger outlay of money and a return on the investment which can reasonably be expected to come back only after a lapse of some time and which in its scope would improve a waste area on a wide front, and works of improvement affecting restricted areas. The funds for the reclamation of the former type should, in the opinion of the Committee, be forthcoming mainly as a grant or partly as a grant and loan at a concessional rate from Government. As regards the expenditure necessary for works of improvement which affect a particular portion of a district or village, the Committee recommend that approved works of improvement should be carried out with the active consent of the zamindars and cultivators, and assistance from Government, financial and technical, should be forthcoming. They recommend that when advances are given under Act XIX of 1883 or Act XII of 1884, the district 'Authorities' should be vested with discretion to recommend to the Board that the loan that should be given should bear interest at a concessional rate or should bear no interest at all and payment back of the loan should be spread over convenient instalments so that, as is the object of the Act, the loan charge could be met easily from the increased profits of cultivation. The Committee are not in favour of acquiring outright any area for the purposes of its reclamation or improvement except under the Land Acquisition Act after going through full formalities under the Act. The land can only be acquired by Government.

The Committee are in favour of arranging for leasing out areas with the consent of zamindars and cultivators affected so that the area might be developed with due regard to the interest of everybody concerned from a loan borrowed under the above-mentioned Act or a grant made from Rural Development Funds.

The Committee lay emphasis on the fact that the work of reclamation and of taking necessary precautions to prevent erosion should be carried out by persuasion and active co-operation of the zamindar and the cultivators concerned. But where this active co-operation is not readily forthcoming and where the Board feel that in the circumstances stated under section 35 of the Forest Act it is necessary to impose certain line of conduct on the owner of the waste land by way of his taking positive action or refraining from acting in a particular manner, the existing powers of local Government may be entrusted to the Waste Land Reclamation Board. Raja Jagannath Bakhsh Singh demurs to the above recommendation. He thinks that the power may remain vested with the local Government as at present.

The Committee are agreed that where a scheme of reclamation or improvement is prepared with the help of experts by a village 'Authority' and the district 'Authorities' approve of the scheme, then the

latter should be empowered to sanction any proposal forthcoming from the village organization for taxing itself to meet the cost of improvement or reclamation. The Committee at present are not in favour of vesting the district 'Authority' with the power of levying taxation on the villagers affected by the scheme of improvement unless the proposal comes by mutual agreement from the villagers themselves.

The Committee feel that *usar* tracts are '*usar*' in practice because nobody has seriously and systematically cared to reclaim them. By their very nature they serve as common utility areas wherein by common understanding of the proprietors of land the cultivators release their cattle for purposes of roaming and picking up scanty herbage. The old saying of Arthur Young comes true : 'The sense of ownership would turn sand into gold.' The moment some individual or a body of men are made to feel an interest in the ownership over this area, that very moment would be born the incentive to improve that area. Improvement with the free labour of the villager was a practical proposition when the common utility land was really controlled by the village community but with the coming in of a distinct tier of 'owner-class' as apart from the cultivator class, the interest in the exercise of ownership waned. The people who had free labour to give were not identical with those who could utilize that labour for improving these areas. *Usar* is the tragedy of the divorce of the labour-pool from the ownership-pool. Let a conduit pipe be established in between and the Committee feel that the sense of ownership and individual benefit will turn *usar* into tractable area. Expert departments have given up prolongation of experiment on certain lines in the past merely on the question of costs. The problem has not been tackled in areas where *usar* is limited in extent and interspersed between cultivated areas, and whether this waste could not be rendered less intractable by the free labour given in the spare time of the villager so long as villagers as a body are in a position to reap the benefit of the work done on that area. The Committee are irresistibly driven to the conclusion that apart from areas which are susceptible of large-scale reclamation or improvement, the major portion of the area which is mixed up with cultivation is only susceptible of exploitation under the auspices of the village *panchayat*. The zamindars' rights in land have to be acquired by a lease to be taken on behalf of the whole society and thereafter under the direction of expert departments the local authority should be in a position to lay down the line of action to be adopted so as to make these *usar* areas serve the purpose in the most efficient manner possible of the village community. The Committee feel that as long as this question is not faced fair and square and the rights of the parties, i.e., ownership on the one hand and easement rights on the other, co-ordinated, there is little prospect of successful reclamation or improvement of waste land areas. The main purpose of this Central

Authority will be to help the District Organization in any scheme of reclamation or amelioration with contributions wholly from Government or by grant on contributory basis, or merely with advice. The Committee strongly feel that in areas where *usar* or *reh*-encrusted *usar* has been found to be the result of any defect in the working of the canal system, no funds should be grudged to the Canal Department, which after all is a commercial department, for expenditure on the construction of drainage cuts necessary to drain out seepage water or water the movement of which has been interfered with by the construction of the canal. If water is needed for purposes of washing out the injurious salts, canal water should be provided free of cost till the land becomes sufficiently free of deleterious salts to permit of growing of crops. The Committee feel that water is very precious ; but, where deterioration has been brought about by the faulty alignment, it is due to the villagers that their land should be improved on lines indicated above.

The Committee urge that with a view to disseminate correct information about reclamation of *usar* in villages, demonstration plots should be set up to try ameliorative methods indicated above with a view to find out what would be the most suitable methods to adopt for a particular tract, keeping in view the resources of the cultivator and the capital expenditure which it would be possible for a business man to incur. Any expenditure incurred in the maintenance of these demonstration plots will be money well-spent in translating the results of laboratory-scale research work into actual practice under condition in which the average cultivator lives and has his being.

The Committee have been informed that wherever extensive plains of *usar* and *reh*-encrusted *usar* occur, the trees that generally thrive are *dhak*, *babul*, *ber*, *karail* and *neem*. It is necessary to find out whether the soil on which these trees stand is freer from deleterious salts as compared with the soil in the neighbourhood which is bereft of any vegetation. We further would recommend taking up soil profiles in these areas for detailed analysis with a view to ascertain the possibility of establishing a thicker fuel preserve. The Committee feel that it has not hitherto been possible to concentrate on the work of afforestation in the plains for the purposes of fuel plantation. The emphasis has been more on growing of timber trees or any plantation so as to prevent erosion. Time has come when the question of village forests must be tackled in a systematic manner. These experiments should be conducted in areas under the control of Better-Living Societies. The Committee feel that, with free labour available for the construction of *thalas*, planting of trees and their subsequent care, better results could be shown on these *usar* plains in the direction of building up of a fuel preserve. The question of property in the tree planted must be satisfactorily solved on some understanding between zamindars who own these areas and the tenants who would be expected to

plant the trees. The Committee in the end would emphasise the point that these reclaimed areas should be given back in one shape or the other to the service of the bovine animal for whom village economy in the past had set them aside. Afforestation with fuel trees would release cowdung for the cultivated field and preservation of grass on partially reclaimed areas which are closed to grazing would yield large crop of grass for cattle.

Before making definite recommendations we cannot lose sight of one fact that we are not confronted in the United Provinces with the acute problem of increase in the salinity of the soil as a result of which nearly 40,000 acres are being rendered unfit for cultivation every year in the canal-commanded areas of the Punjab. Dr. Puri gave us to understand that they were concentrating on the problem of reclaiming such areas and preventing good areas being thrown out of cultivation on account of the rise of the saline zone up to the root level and above. As a matter of fact, it was only in certain districts of Meerut Division, as it was then constituted, that the introduction of the canal led to waterlogging or rise in the water-table and appearance of *reh* on the surface of the soil. The defect was soon remedied by provision of more drainage cuts. Dr. Leather had noticed various patches of *usar* in the area that subsequently was to be commanded by the Hathras Branch. The Settlement Officer of Aligarh has recently reported that as a result of the introduction of the canal, these *usar* patches that existed in 1914 have not increased. On the contrary, these patches form part of holdings which are now receiving liberal irrigation water and are constantly under crops. Cultivation in the neighbourhood has stirred up the sterility of these *usar* patches and even they are showing signs of grass springing up. It clearly shows that there is no seepage in this branch in areas which had patches of *usar* and that there has been no rise in the water-table and no disturbance in the salts lying in the soil horizon. The principal reason for this state of affairs is the nature of the soil through which the canal flows. The soil in certain places is intensely packed and impervious. It is not porous as in the Punjab. Improved cultivation in the surrounding area has improved *usar* patches wherever such experiments have been undertaken in the United Provinces. It has been noticed that wherever any but the worst *usar* is closed to grazing, grasses spring up and ultimately superior kind of grass with better nutritive value establishes itself. It is in this direction that the ordinary *usar* area will have to be dealt with. It is because nobody has seriously considered the problem of planning out the improvement of this area that the area is *usar* in the strict sense of the word, i.e., uncultivated. Planning is strictly necessary together with control of grazing according to rules laid down under the planned economy. The second thing that could systematically be taken up would be planting of trees done by the villagers themselves. They recommend the forest method of planting on the

ridge and trough system. Immediately trees are established in such an area, the soil would be enriched by the humus of leaf-mould and fallen twigs and this will have a tendency to improve the permeability of the soil, and what were barren patches before will begin to get some kind of grass. The Committee recommend that once the area is closed to grazing, the subsequent admission of cattle in the closed area should be strictly regulated.

CHAPTER III

RECLAMATION OF OTHER WASTE LANDS

The total acreage of culturable waste is nearly 99 lakhs (*vide* Season and Crop Report, 1937-38). This is made up of culturable waste of 79 lakhs, old fallow 7 lakhs and groves 13 lakhs. Under paragraph 101 of the Land Revenue Manual, fallow after seven years is recorded as culturable waste. The area of culturable waste includes land which is out of cultivation for more than seven years as well as other land covered with bush, grass, etc. The test of cultivability is the capacity to grow some kind of grass. The total amount of culturable waste in 1937-38 was 85 lakhs odd acres ; and 13 lakhs odd of groves, but the former includes 6 lakhs of forests not managed by the Forest Department. This leaves 79 lakhs of acres as pure culturable waste. Paragraph 129 of the Manual of Revision of Maps and Records lays down that the word '*parti*' is to be applied to land which is known to have been under cultivation within the last seven years, and the word '*banjar*' (culturable waste) is to be used for land not cultivated for the last seven years. It would be thus clear that the moment *parti* becomes more than seven years old it becomes *banjar*, but not all *banjar* has once been cultivated, and here comes in the artificial nature of the definition of *banjar*. There is an undefined partition between *banjar* and '*barren*' land because the barren land includes *usar* and *reh* plains of nearly 21 lakhs, some of which do bear on their surface some grass or *dhak*, *shisham* and *babul* trees. Mild *usar* is susceptible of cultivation and is actually sown with rice in eastern districts. Paragraph 100 of the Land Records Manual gives the patwari scope for changing the class of the land described in the Land Records ; but the patwari is overworked nor is he technically equipped to note the change and the result is that the *banjar* area remains stereotyped at a figure which is not subject to a critical test. The Committee feel that some portion of this area is certainly barren while in the '*barren*' group are included areas which are susceptible after treatment of bearing crops. The Settlement Officer has not been interested in working out the reasons which have led to nearly 25 per cent. of the cultivated area being recorded as culturable waste. The area is not directly assessed to revenue and it

is an only inconsiderable portion that yields *sayar* income and is assessed to revenue. The moment, however, an organization like the Waste Land Reclamation Board envisages the problem from a comprehensive point of view, the necessity for soil classification will be obvious and we feel that in no distant future the headings of our Land Records Department will have undergone further differentiation and soils which are at present not capable of bearing food crops might in future be found more precisely classified into crop-bearing areas, grass-bearing areas, tree-bearing areas and barren areas. It is tantalizing to feel that there is such a huge area described as culturable and yet is not cultivated. The ingenuity of man stands self-condemned at the bar of public opinion when with the pressing problem of more food for the growing population of more men and cattle we are allowing this huge potential hinterland remaining undeveloped. The Committee venture to offer their considered opinion on how this vast area is to be harnessed to the service of man and his companions in agricultural co-partnership—the milk-giving cow and the plough-dragging team of bullocks.

Most of this area, except where extensive *banjar* areas are noticeable in parts of Jaunpur, Azamgarh and Fyzabad in the eastern districts, and Etah, Etawah, Mainpuri and Aligarh in the western districts, are comparatively small areas inter-mixed with cultivated fields in the *had-bast* villages. In the United Provinces we have altogether a little over one lakh of villages. If an average is taken it gives 80 acres of culturable waste per village. But a fallacy lurks in this average. The area diminishes as we travel from west to east and it is lying scattered, interspersed in chess-board pattern with cultivated areas. As the Census Report has definitely shown, the pressure of growing population on the culturable area available for cultivation is growing decade by decade and yet the Committee feel that the state of *petite* culture or intensive cultivation that is practised on an extensive scale in France and in Japan has not come in except in areas near cities and towns on lands cultivated by the skilful class of *Murais*. Nothing has been done for the systematic utilization of these huge so-called pasture areas which dwindle as we go from north-west to south-east and when we reach certain parts of Oudh and the Gorakhpur District we find that the pasture areas are reduced to what might be described as precarious footholds for the starved cattle. There is not enough room for them to move about. The Committee before describing the various methods of utilizing this area for the benefit of men and cattle would lay emphasis on the *leit motif* that should run through any scheme of long-range systematic reclamation of these areas.

In the first place, what is needed is some kind of statutory authority which would lay down that a certain area in every village ought to be under trees and grasses and if need be have power to acquire with consent of the various interests concerned, this area for this purpose. On the other hand, where these areas are available there should be

authority for closing portions of the area to grazing so that the natural grasses might assert themselves. This closure should be secured as far as possible with mutual consent of the parties concerned.

The Committee would also urge that contour *bundhis* should be put up so as to impound as much water as possible, which at present goes waste, carrying with it some of the most fertile part of the soil and for that purpose *watbundhi* weeks should be observed as they do in the Punjab as often as possible during the year to keep these field embankments in good state of repairs and construct these where necessary.

The Committee would emphasise the fact that even if some area out of this *banjar* is brought under cultivation as is sporadically done by cultivators who *bund* up the area, wash out the injurious salts and put the area under paddy, the main objective should be to increase the food available for cattle. It is with this point in view that we have to judge all the efforts so far made and indicate the necessary authority for bringing about the utilization of this area in the best interests, in the classic words of Mr. De Valera, of 'the peasant and the steer.'

Before the Committee recommend the actual steps to be taken for reclaiming waste lands on large scale or as part of *petite* culture as practised in villages, they have to consider the type of the organization that would undertake this work and the consideration of the existing rights of easement which cannot be lightly pushed aside.

What we have to overcome is the existing reluctance of zamindars to combine and getting the villagers who have grazing rights in these areas to agree to the grazing being controlled under some system of closure. It is necessary to have statutory authority behind large-scale manipulation. Either (i) the area is to be leased out to Government on a nominal rent on the condition that it will be returned to the original owners on payment of the actual cost of improvement and provided also that the improved land on return will be exploited under certain restrictions; or (ii) power may be taken by Government to acquire outright certain areas situated near big cities for the purpose of improving them and then selling the area to be exploited under certain conditions.

The Government have before them sufficient experience as regards leasing out of areas for improvement in the ravine area of the Jumna and Chambal in Etawah. The Forest Department are working on those lines. The Agriculture Department have recently acquired certain areas for experimental purposes on more or less similar terms. The problem of reserving the rights of the cultivator in the pasture areas acquired by the departments has not been envisaged in its true perspective. The canvas on which the picture is so far drawn is limited. When we recommend, however, the question of taking up

these areas for improvement on a largescale, we have to consider what is to be done with existing rights to grazing. The Forest and the Agriculture Departments who are interested in these experiments must devise a method of rotational closure to provide for certain areas to be always available for grazing and for growing fodder so that the available fodder supplies of the villagers would not be seriously curtailed. The legislation that would be undertaken would provide for rule-making power so as to regulate the working of the scheme of reclamation with a view to see that existing rights are as far as possible respected. Where Government acquire an area outright, as in the case of Juhi experiment, the question of making any reservation for existing rights does not arise. The Government are in a position thereafter to develop it in such a manner as to make the area a model for other zamindars working on large-scale basis to follow and before this area is sold, certain conditions will be entered into in the sale-deed by which the sale will be nullified if the estate is worked on lines which go counter to the directions of the authority which will be invested with the rule-making power.

Where a zamindar proposes to take up the question of reclamation, the local authority should enable him to take up the question of improving waste areas provided that he abides by the rules made under the Act to safeguard the rights to pasture that the cultivators enjoy at present. On the other hand, where the village community or the Better-Living Society proposes to tackle the problem of improving the waste areas, the Act should give them authority to take the area concerned on lease from the zamindari body and the lease will be binding on the zamindari so long as the estate is worked on lines laid down by competent authority. The rules will make clear provision for enabling the zamindar's cattle to obtain their share of grazing in any scheme of closure that may be applied. The Committee are opposed to compulsory acquisition of these common utility areas which belong to zamindars but in which the cultivators enjoy easement rights. The Better-Living Society will have to pay reasonable rent to the zamindari body and will on its side derive benefit from the ultimate improvement of the area leased. Once the statutory authority decides that a particular area is to be improved, the landholder is given the option either to take up the improvement himself or make over the area to the appropriate Government department for its improvement. If the latter is not prepared to accept the offer because the programme of improvement outlined for the area does not admit of that area being taken up, then the alternative is to give the option to a local Better-Living Society to take up the work. If, however, neither the zamindar nor the local Better-Living Society is prepared to take up the work, then it should ultimately come in the Government's programme of improvement, and there should be statutory authority for obtaining compulsory leases of these areas for the Government on conditions

that, on the one hand, will safeguard the existing rights as far as possible and, on the other, will enable the Government to recoup the expenditure it has incurred on improving the area before it is returned to the rightful owners.

The definition of integral land reclamation which is given by Professor Serpieri dealing with *bonifica integrale* affords a great deal of pertinent significance to the objective behind rural reconstruction work in the United Provinces. 'It consists in the co-ordinated execution of all the works required to adapt the land and water on it to such intensive forms of productions as will ensure work and higher social standards to a dense rural population.' We have to envisage the problem of waste land reclamation so far as the land is reclaimable for the growing of crops that would be most useful for the all-round physical and economic development of the cultivator. We have not only to provide him with food but also for his cattle, in order that his cows and bullocks would have enough fodder in the shape of grass, corn stalks, leaves, etc. We have to see what is the present incidence of grazing in these provinces. The following statement may be seen :

Incidence of grazing in the United Provinces

Civil Division	Districts	Total grazing area in thousand acres	Total domestic animals in thousands	Grazing incidence	
				Acres per animal	Animals per acre
Meerut ..	Bulandshahr ..	176	726	·24	4·1
Agra ..	Aligarh, Mainpuri ..	232	1,588	·15	6·8
Rohilkhand	Bareilly, Budaun ..	282	1,645	·17	5·8
Allahabad ..	All five districts ..	1,152	5,168	·22	4·4
Benares ..	4 districts excluding Mirzapur.	437	3,135	·14	7·1
Gorakhpur ..	All three districts ..	754	5,196	·14	6·9
Lucknow ..	5 districts excluding Kheri.	1,150	5,160	·22	4·5
	Average of 20 districts	4,183	22,618	·18	5·4
	For bovine cattle only, average 20 districts.	4,183	16,492	·25	4·0

It shows an incidence varying from 4 to 7 animals per acre for twenty selected districts with an average of nearly 5½ animals per acre.

for all the animals or 4 bovine cattle per acre. Our pastures are none of the best. Mostly they are uncultivable land and certainly inferior in their capacity to bear fodder. In America they have worked out grazing incidence of 14 acres per animal. In this province there is no control of grazing over the limited area that is available with the result that the pastures get no rest and areas are being denuded of vegetation resulting in erosion and rapid run-off of water instead of water being impeded in its progress and absorbed by the soil.

The following aspects of the problem were considered by the Committee :

(i) that the chief economic use of waste and alkali lands at the present time, and for many years to come, is as grazing grounds for domestic animals ;

(ii) that the excessive grazing incidence destroys the natural vegetation, accelerates run-off and floods, and greatly reduces the fodder production ;

(iii) that the more successful the Committee are in evolving methods of reclaiming *usar* for cultivation, the worse will be the position as regards the grazing on the remainder ;

(iv) that limitation of grazing incidence and rotational closure will tend to counteract the evil effects indicated in (ii) above and is essential to increase fodder production and to check run-off ;

(v) that this essential measure is only possible by reduction of total number of animals, or more stall-feeding and increased cultivation of fodder crops, or preferably both ;

(vi) that action need not await further detailed research, but should be taken as soon as possible.

We are told that either we must materially reduce the number of our cattle or we must grow more fodder crops as part of our rotation and resort more and more to stall-feeding. We have been told that for the United Provinces as a whole there are fewer than 3 acres of cultivated fodder crops per 100 animals. In Gorakhpur and Benares Divisions, where grazing areas are very limited in extent, there is only one acre of fodder crops per 100 animals. If the agriculturist, therefore, is to prosper, then any reclamation of this waste area for purposes other than growing of fodder crops has been considered by many to be suicidal in the interests of the agriculturist himself, as his well-being chiefly depends on the health of his helpmate—the bullock.

There is, however, one aspect of the question of waste land reclamation that should not be lost sight of. If we succeed in bunding up areas which are at present lying infertile and carrying on the surface

scanty tufts of grass here and there, and preserving the area from indiscriminate grazing, there is the possibility of superior grasses finding a foothold in the area and ultimately establishing themselves. It is possible to grow leguminous crops which may serve as fodder and thus build up a good meadow land. It has been calculated by experts that a small fraction of the normal area that would have provided grass on the present unimproved form of *usar* will ultimately suffice for growing in its improved condition sufficient fodder crops to meet the existing requirements. No antinomy really exists between the aforesaid postulate advanced by the experts of the Forest Department, who are interested in afforestation and closing areas against grazing so as to raise the maximum amount of fodder and those who urge that if stall-feeding is once resorted to, the fodder required by the cattle would be made available from these very waste areas, parts of which are styled grazing areas, after being subjected to proper closure, cultivation and subsequent reclamation as good land. The area may bear crops but its rotation is to be so arranged that there will be fodder crops and the chaff and stalks available if the food crops are grown should be plentiful to meet the growing needs of the bovine species.

The most important problem about the reclamation of patches of waste land included within the village area is the problem of its utilization after reclamation. At present it is generally a common-utility area on which there is slight growth of grass of an inferior variety during the rains. Otherwise, it stands as an apology for pasture-land, and after the rains it is mostly used by cattle for moving about and taking mild exercise. It may be possible by restricting the ingress of cattle in this portion of the area to make this land fit for the growth of vegetation by ploughing, storage of water, leaching of soils, opening out the soil particles and making the land approximate to the ordinary type of soil. But if it is to be put under a crop which would yield more food grains than fodder, then where will the cattle go for the physical movement that is necessary for them and where will they get the grass they used to get in the rains on this village *usar* patch? The ideal arrangement is to obtain a lease of this land, which generally belongs to the zamindari body, on behalf of the local Better-Living Society, and if the area is of sufficient dimensions, then it can be divided up into two or four compartments and half of it can be closed to grazing while the other half is kept open. On the area closed to grazing can be grown grass in the rains which can be cut twice during the season and stocked in silos. In the area that is left open for grazing cattle can be admitted on payment of a small fee. This will necessarily reduce the number of useless cattle that usually burden the poor pasture-land of the village with too much stock.

We examined the Rural Development Officer and wanted to find out whether there would be voluntary curtailment of the right to free grazing in the whole village pasture-land in case half the area is closed

to grazing with a view to improving the grass. His opinion was that if the area remained under the control of the zamindar, the tenant would not voluntarily forego his right of free pasturage and there would be trouble in the village. The solution lies in the area being leased to the Better-Living Society. It will admit cattle of the tenant as well as of the zamindar on some basis of regulated admission.

The Committee recommend that if it is not possible to fix up systematic plantation by the zamindar, the area could be acquired on behalf of the Better-Living Society for the purpose of planting a village fuel preserve. At present everybody's land is nobody's land and our pasture areas do not bear the grass they should grow and feed the cattle population in the way they should be fed.

The Committee realize that it has been after a very bitter controversy raised on the floor of the Assembly and the Council that an agreed solution has been arrived at as regards tenants' right to plant trees in their holdings and this solution has been embodied in the Act that has finally emerged from the Assembly. They feel that without creating any further rights in the areas put under trees in favour of tenants over and above those rights given to them under the Act, a gesture is necessary from the side of Government to induce landholders and tenants on an agreed basis to put more area under trees so as to approximate to the ideal condition of having 20 per cent. of the village area being put under trees. They recommend that areas which at present stand assessed to revenue should be shown the same concession as regards remission of revenue as is within the existing powers of the Collector to show to the planters of groves on assessed areas during the currency of settlement. The rights of the planter of trees will, subject to the tenancy legislation, depend on agreement between the landholders and the planters of trees. The Tenancy Act allows planting of trees on certain portions of cultivated land so long as no grove rights are claimed in that area. The local authority should be in a position to decide in what compact blocks of the village, fuel and fodder preserves are to be set up and, if any cultivated area comes into the scheme of afforestation, the law as it stands at present saves the tenant from ejection. This legislation will help in the plantation of *taungya* or plantation of trees on agri-silvicultural lines. *Taungya* plantation was begun in Saharanpur on good soil. Subsequently it is being established, as will become clear from a very interesting note of Mr. Sohan Singh Negi, incharge of afforestation work, both on culturable land now lying waste as well as on cultivated land. The whole object of the *taungya* plantation is to create an interest in the villager in the rearing up of trees. In between the trees they have been allowed to grow crops. So long as the trees have not attained a certain height and not built up a canopy at the top, the cultivation in between flourishes. The Committee feel that though

great is the need for building up a fuel preserve which would release cowdung for manuring his land, greater is the necessity for rendering land available for the growing of grass, and in spacing the plantation of trees under the *taungya* scheme, the fact should not be lost sight of that the distance between tree and tree should be such as ultimately to render it possible for the land in between the trees to bear a good cover of grass. The Committee very strongly recommend that for the pasture-land of each village this question of plantation should be taken up in a systematic manner. If the area is not sufficient, one or more villages should combine and establish village forests and village grazing areas in consolidated blocks. The Committee would suggest that every encouragement should be given to zamindars to allow tenants to reclaim these waste land areas at their own cost on some such condition that the area would not bear any rent for a definite period, and, thereafter, the pitch of the rent would gradually be allowed to work up to the settled rate.

Where zamindars are prepared to reclaim a particular area which at present is lying waste, the Local Authority will lay down conditions on which the zamindar at his own cost will reclaim the area in the best interests of the village community. It will frame rules for the utilization of this area by the village community on lines which would allow of the cost on reclamation being reimbursed to the zamindar within a certain period of time. The lease will be so arranged as to allow of certain other area being available for common utility purposes like grazing, etc.

The Government of the United Provinces were very much exercised over the question of depletion of underground reservoirs of water by the pumping that is continuously carried on 3,000 hours per annum at 1.5 cusecs per hour. In this connexion the geological nature of the alluvium came to be reported on by Mr. Auden, Assistant Superintendent, Geological Survey of India. He reports that in the west of Meerut and Muzaffarnagar, the alluvium is thin on account of the submerged Aravalli range ridge, but over the greater part the alluvium is thicker on the average than the depth of 240 feet of the tube-well. A reasoned estimate is 2,000 feet or more. The alluvial area must be considered as a single unit. Water falling in the higher rainfall area of the Tarai is certainly operative in replenishing the ground supply. Sands predominate over clays and the proportion of sands in clays is likely to increase towards Tarai. The clays occur in constant lenticular beds within the very general and inter-connected sands. Since the *bunds* are inter-connected the water contained in them must occur as a single reservoir. The geological information available to us in the report explains the sandy nature of the alluvium in parts of Meerut, Moradabad, Bijnor, Budaun and Muzaffarnagar. The Committee has scrupulously avoided the use

of word ' *bhur* ' because *bhur* has a peculiar significance as descriptive of a class of soil, and we have *bhur* 1 and *bhur* 2 soils in Moradabad. They are all sandy soils. Their main deficiency consists in the absence of organic matter which serves as binding material.

Bhur soils

Experiments on afforestation on sandy areas have been carried out by or under the advice of the Forest Department on a limited scale on waste lands in Bareilly, Budaun, Agra, Lucknow and Meerut Districts, and in canal areas to improve avenues on canal banks.

The natural vegetation of *bhur* soils is generally a growth of *kans* grass (of no value) and *patas* used for thatching and *munj* grass (useful for thatching and inferior string or rope).

The results of experiments carried out up to date have been variable. In the Meerut District (Khan Bahadur Wahiduddin's sandy land) the primary object of the experiment was to stop the shifting sand dunes encroaching by wind action on valuable cultivation. Results here were most successful. In the Bareilly area, a rather indifferent plantation of *khair* trees (*acacia catechu*) has developed, while in the Budaun area, an interesting plantation of *baib* grass (for which an enormous demand exists for manufacture of paper and *ban-rope*) has been established. In the Kheri District extensive and highly profitable plantations of *baib* grass have been made on sandy soils, somewhat more loamy than real *bhur*.

On the Lower Ganges Canal there are fairly extensive lengths of *bhur* ; and here remarkably good plantations of *sissu* and *khair* have been made. On the other hand, at Runkutta in the Agra District, plantation development has been rather disappointing, while the plantation on the semi-*bhur* portion of the Lucknow Improvement Trust-area and Salimpur land has completely failed.

Over 50 years ago, Khan Bahadur Sheikh Wahid Uddin of Meerut arranged for the protection of a *khola* area near Meerut from grazing. No other special measures were taken and the area was again open to grazing. The results are extremely interesting. A scattered crop of *shisham* came up which ultimately grew to fine dimensions. Two years ago, the proprietor sold 75 per cent. of the established *shisham* crop for Rs. 20,000. This sum represents clear profit as the expenditure in cash was nil. The closure against grazing was in force as a result of Khan Bahadur's persuasion. As regards reafforesting the area there would be not the slightest difficulty and it would be possible to add more valuable species like *khair* and bamboos for which there is a ready demand. It was found by experience that all the graziers wanted was free access to the *khadir*. The prescription of the Forest Department consisted in closing the area for browsing by cattle and allowing nature to reassert itself. Steps were to be taken

lished itself. Another area was to be enclosed where there were *sissoo* trees. This enabled the Department to find out how far closure contributed to the establishment of natural vegetation. Not only it prevented erosion but yielded at the end of a definite period a valuable crop of timber as clear profit to the zamindar.

In 1913 about 28 acres were taken up for experiment by the Forest Department on the request of Khan Bahadur Sheikh Wahid Uddin. *Shisham* and *babul* trees were sown. Further species were added, namely *sisis* and *khair* and all that was needed was protection from grazing. One of the inducements to the tenants to keep their cattle off would be in the shape of free supply to tenants of small poles available from thinning. This practice, in the opinion of the Committee, should be brought to the notice of other zamindars as a most effective method of securing co-operation of tenants for enforcing the closure to grazing in certain areas.

The Committee are of opinion that sandy areas are susceptible of yielding quick results to the efforts of the silviculturist. Once trees have been established, it is found by experience that the main deficiency of these soils, namely, lack of organic matter and absence of cohesion in the soil particles, is made up by the natural absorption of fallen twigs and rotten leaves into the body of the soil. It is noticed that the soil crumb is in a better position to retain moisture and render the soil suitable for growth of rich grass. The plants which are found to do well immediately are *sissu* (*dalbergia sissu*) and *khair* (*acacia catechu*), *baib* grass (*pollinidium angustifolium*) which is in such a huge demand for paper pulp. The trouble in *bhur* soil is the difficulty of sinking *kachcha* wells. The sides do not stand and unless masonry wells are sunk, cultivation of food crops is impossible. We have found by practice that the inclement character of the sandy soil immediately becomes changed with the establishment of the canopy of leaves of the trees and the resulting change in the humidity which minimizes evaporative forces and helps in the conservation of moisture in the soil.

Areas constituting thin poor soil occur in the United Provinces in the Mirzapur District and in the south-west of the Allahabad District bordering on Banda, locally known as *patha* soil. The Committee would suggest the following measures for amelioration of these soils :

(i) Considering that the run-off on such areas is excessive the necessity of putting up contour *bunds* at the head of slopes is indicated so that, on the one hand, the scouring of the soil constituting the top layers be prevented and, on the other hand, greater accumulation of silt and finer particles of soil brought down from the upper reaches of the land may be brought about with the result that the soil which is thin and is incapable of retaining water may gradually develop into a comparatively

thicker stratum with a higher humus content as a result of the retention of the leafy material received by it along with the soil particles flowing down from the overlying slopes bearing forest vegetation.

(ii) All possible steps should be taken to encourage the growth of grasses and cover crops. Steps should be taken rigidly to control or even to prohibit grazing, grass cutting and the lopping of trees and shrubs so that the growth of natural vegetation may be encouraged as far as possible. The Forest Department have achieved marked success in the afforestation of *Bhabar* areas which are lying uncultivated on account of difficulties of irrigation and absence of resident cultivatory population.

(iii) According to Dr. Puri's evidence before the Committee, it is suggested that, wherever possible, superphosphate at the rate of 100—200 lb. per acre be applied in combination with farmyard manure or compost so as to prepare the soil for raising crops. This would, it is believed, improve the thin soils to an extent which would enable the root system to develop properly and thus help the consolidation of the soil.

Waterlogged soil

The Committee feel that the principal item in a scheme of amelioration of lands of this type must be the provision for good drainage. In most cases, not only surface but sub-soil drainage is called for, depending on the nature and topography of the soil.

Wherever waterlogging is brought about as a result of seepage from the adjoining canals, greater attention should be paid to the realignment of the canal, provision of more effective drainage channel and, if necessary, lining the canal beds and sides, as they do in the Punjab, to minimize the effect of seepage.

After adequate drainage has been provided, the land should be brought under cultivation or suitable species of grasses grown.

Mr. Gillan, Settlement Officer, Meerut, devoted considerable attention to the spread of *reh* and waterlogging in the *khadir* and low-lying tracts. He was of opinion that *khadir* had deteriorated in recent years owing to the spread of *reh* but he thought that the canal was not solely or chiefly to blame for the waterlogging. Mr. Gillan's views have been justified by what Mr. Cooke, the present Settlement Officer, has subsequently observed. There is an increase of 42 per cent. in the cultivated area in the *khadir*. That does not justify any deterioration on account of *reh*. *Reh* appears and disappears capriciously and the big floods in 1924 appear actually to have benefited the Jumna *khadir* while damage to the Ganges *khadir* was only temporary.

In this connexion, it is interesting to note that at least in the Punjab recent soil surveys do not lend any support to the popular view that the rise of water-table is responsible for the spread of salts on the surface soil. Mr. M. L. Mehta, Land Reclamation Officer, Punjab, in his evidence before the Committee produced a statement showing a list of villages with water-table varying between 9 and 40 ft. from the natural surface and yet *thur* (salts) was spreading in all these areas. An examination of soil profiles in the Punjab in villages with deep water-table showed that the soil crust was not more than 10 ft. thick underlying which was all sand. There could not possibly be any connexion between the soil crust and the water-table through a 30 ft. layer of coarse sand.

Thakur Manak Singh raised the point whether installation of tube-wells along some of the main canals where waterlogging has occurred would effectively reduce the water-table to a lower depth apart from the redundancy of such wells near canal areas. The technical evidence before the Committee does not, however, support this view. In this connexion, the opinion expressed by Mr. Mehta of the Punjab was that digging of surface drains instead of installing tube-wells would be a better proposition as the former set in motion the water-table whereas the latter tended to keep it stationary. As an instance, he pointed out that at Chakanwali where considerable waterlogging had occurred, no difficulty was felt in raising good crop of sugarcane, rice, wheat and cotton by merely providing drains, in spite of the fact that even with adequate drainage arrangement the water-table at the end of ten years remained where it was, i.e., varying between 6 inches to 3.5 ft. from the natural surface. Tube-wells were installed and it was found that constant pumping did not affect the water-table beyond a radius of 3,000 ft. Directly pumping stopped, the water-table came up to its original level.

The chief trouble in the United Provinces lies in the fact that the physical texture of the soils is defective in the sense that the growing plants are unable to thrive because of the hardness of the soil which does not allow the roots to penetrate deeper, specially during the earlier stages of growth. Examples of such lands are somewhat common in the province. Two samples of this type of soil—one from Ghazipur and the other from Clutterbuckgunj have been analysed and the analytical figures are given in detail in Appendix Part I(3). It is obvious that neither the pH value nor the quantities or the nature of the salts present can be taken to be the primary causes of the soil infertility in these cases. The main problem therefore is to bring about an improvement in the soil texture by making it more porous and open. This can be effected by adopting the methods already suggested for the treatment of the alkaline and saline lands.

In the Bombay-Deccan fairly extensive areas of this type of land known as 'chopan' have been reclaimed by providing for deep sub-soil drainage followed by cultivation with green manuring like *dhaincha* (*sesbania aculata*) and application of gypsum or sulphur.

Bhabar and Tarai Tracts

As regards land lying uncultivated on account of sparseness of population and unhealthy climate such areas are almost wholly restricted to the Bhabar and Tarai tracts in the United Provinces.

Since 1910 onwards Government have been alive to the necessity of ameliorating the conditions in these tracts; but it appears that almost all the efforts made so far have proved somewhat futile. A Committee for the improvement of the Tarai and Bhabar Estates is sitting even now and their recommendations would prove valuable in many directions.

The chief difficulty in the Bhabar area is that every pailful of water available for irrigation has been earmarked for the present cultivated area and nothing is available by way of increased supply of irrigation water to increase the area under crops requiring irrigation. The Government reserved forests are under valuable *sal* timber and the Forest Department are in one way or other controlling this area. *Baib* grass also grows well in the Bhabar tract. From the districts of Naini Tal, Saharanpur, Gonda and Dehra Dun, the Forest Department supply nearly 6 lakhs of maunds of *baib* grass annually to the Paper Factory at Saharanpur. From the forest areas, where *baib* grass grows in Pilibhit and Bahraich, an annual supply of 60,000 maunds goes to the Paper Mills at Lucknow.

The soil of the Bhabar tract is very porous and it is almost impossible to hold water by impounding. In the Bhabar Government Estate the crops grown are *ganara* rice, a coarse but high yielding variety of the *sathia* type, and sugarcane. Generally *ganara* rice requires about .5 waterings. Under existing conditions it is possible to get water for the canals for about 20 days in the year from Bhim Tal for the irrigation of paddy and sugarcane in the Bhabar tract. Wherever water-supply is not the limiting factor, e.g., in the 32 villages of the Chorgalia Block, the success of the crops is more or less assured; but otherwise, cultivation is only possible under very precarious conditions.

The Committee would suggest the introduction on experimental lines of certain hill varieties of drought-resistant paddy which have been found very useful in the Punjab. Such varieties of rice, if established, would lead to considerable economy of irrigation water.

As regards the Tarai tract the main trouble there is bad climate and depredation by wild animals is also a serious inhibiting factor to the spread of cultivation. A considerable portion of Tarai is covered by 'Ullar' grass and other Tarai grasses. At present there is not

much use of these grasses which are being burnt down annually. But these may form useful raw material for paper pulp. The Lucknow Paper Mills have undertaken to conduct experiments to investigate the uses of Tarai grasses for paper manufacture. The Committee should very much like to emphasise the need for finding some useful outlet for the Tarai grasses.

Even at the cost of repetition, the Committee would also like to put the problem of reclamation of the village waste land in its correct perspective.

We must consider the reclamation of this area of culturable waste more or less on the same lines as in the case of reclamation of *usar* and *reh*-encrusted *usar*. The only difference is that, so far as the latter areas go, they are more intractable and need larger outlay of expenditure under technical direction for their reclamation. We have indicated that 'culturable waste' is not in every case a correct description of the areas returned in our Land Records Reports. In many cases, the term "culturable" is scarcely applicable to some of these areas; but, in the majority of cases, given proper organization, technical direction and a sense of property in the reclaimed area, the Committee feel that there is every hope of these areas yielding food and fodder for men and cattle and a minimum afforested area for every village to serve as fuel preserve. The Committee feel that in the United Provinces we are faced with a paradox that small cultivators keep an uneconomically large number of cattle although they are handicapped in the matter of finding fodder for their cattle. It is all, as Royal Commission on Agriculture made amply clear, a vicious circle. The cattle are weak because there is no fodder. More cattle have to be kept to do the farm work because they are weak, and as there are more cattle unless we trench on cultivated land for growing fodder, we shall always have starved cattle in large numbers. The Committee feel that this vicious circle must be broken and this chronic fodder shortage in zones of human concentration, e.g., in eastern districts of the United Provinces has to be made good. A tendency is noticeable of growing *bajra* and barley more and more as food crops. Peas, gram and *arhar* are giving place to sugarcane. What the cultivator should do would be to grow more fodder crops, peas, beans and pulses for the treble purpose of food-stuff, cattle food and soil-enriching manure. Peas have always been known to enrich the soil and provide good cattle fodder. *Arhar* opens out the soil because of its deep roots. The whole thing, therefore, boils down to economic planning in the direction of exploitation of these culturable waste areas. Barring a few districts, about which recommendations would be made by the Committee elsewhere, they feel that the best method of improving these waste areas known as 'culturable waste' would be in making them more efficient to supplement the deficiencies in the villager's life economy. Dr. R. K. Mukerjee is of opinion that the Indian dietary involves a minimum land require-

ment, about 97 per cent. of the food energy consumed by the peasant family being derived from seeds, roots and vegetables. The Committee would draw attention to the following table, showing the sources for calories available in the United Provinces as compared with the Punjab, China and the United States :

Proportion of calories from different class of food

	The United Provinces	Th Punjab	China	United States
Seeds	93.6	75.1	89.8	38.7
Roots and vegetables	3.8	0.3	8.9	9.0
Animal (meat and fish and dairy produce)	0.7	14.9	1.0	39.2
Sugar	0.1	9.2	0.2	10.1
Fruits	0.1	0.3	3.2	3.0
Fats (vegetables)	1.7	0.2	1.8	..

On the basis of an optimum peasant's diet (providing for an adult at least 2,500 calories and 75 grains of protein) and the agricultural production per average holding in the United Provinces (from which deductions have been made for wastage, seed and cattle food), we have estimated that 10 acres can support 11 adults or about 16 units (comprising women and children also). This may be compared with Middleton's estimates for England and Germany.

Relation between cultivated area and population

(Food yielding capacity of 100 acres)

India	100 to 110 persons.
Great Britain	45 to 50 persons.
Germany	70 to 75 persons.

In this connexion, the Committee feel that the example of China is the one to be specially commended to the peasants of the United Provinces. The possible combinations found of the more important winter and summer (second) crops are as follows : in North China, wheat, followed by soya beans, green beans, red beans, cow-peas, sesame, sweet potatoes, millet, carrots, tobacco, buckwheat, Chinese cabbage, onions, hemp, corn, indigo, proso millet and taro ; in East Central China, wheat, wheat and field peas (in association), barley, barley and field peas (in association), rape and broad beans, followed by rice, soya beans, sweet potatoes, and corn. But in order that the soil fertility in the cultivated area can be maintained at its optimum, the Chinaman's assiduity in collecting every bit of farmyard waste matter and

vegetable matter for manurial purposes is to be limited and in this direction the proper utilization of these culturable wastes will help the villager a great deal in getting the necessary fuel for purposes of burning so as to return to the land, as far as possible, what is taken out of the land by human beings and cattle. The Committee recommend that the primary use to which these culturable wastes should be put would be for growing more nutritious grasses and for plantation of trees. The most suitable method of improving grasses would be by judicious compartmental closure to grazing. The spare time of the villager should be occupied in setting up contour *bundhis* so as to collect water and good silt. The Forest Department have officers working on the plains who instruct villagers in the direction of plantation of trees on the ridge and trough method. They also recommend *taungya* plantation on lands which are at present yielding poor crops as well as unculturable waste. The Committee feel that it is in this direction alone that the major portion of this culturable waste can be most appropriately exploited in the best interests of each village. In this connexion, the Committee unanimously recommend that the planning should be to ensure for the village a balanced combination of dairy and cereal farming. It has the obvious advantage of providing for the proper nutrition of the cultivator's family, increasing the income from land and, at the same time, minimizing the risks of over-production of money crops and soil depletion, both of which must be avoided at any cost. The Committee have no hesitation in recommending that the number of useless cattle should be reduced. The following table depicting the position in 4 of the thickly populated districts will be found interesting :

Number per 100 acres of net area sown

	Cows giving 2 seers of milk or more	Other cows	Cow-buffaloes giving 4 seers of milk	Other cow-buffaloes.
Meerut	4.9	4.4	11.6	2.9
Bulandshahr	4.1	4.1	11.8	4.2
Gorakhpur	0.2	17.7	0.6	6.5
Basti	0.08	19.5	0.3	9.5

The Committee realize that, with a strong religious sentiment prevailing amongst the major population of the United Provinces, the decrease in the number of cattle can only be a question of selective preservation and breeding of suitable type. The first step to be taken is some system of compartmental closure to grazing. The second is cutting of grass from closed areas and preserving the same in silos. The third step is, when these improved areas are open to grazing, that

a limited number of cattle should be admitted. Here the selective element would come in and the community would be quite justified in charging a small grazing fee so that the grazing available may be taken advantage of by only the most valuable cattle. Thereafter, having once provided fodder facilities, the Committee would strongly recommend improvement in the breed of cattle and, except in the western districts, the type to aim at would be double-purpose breed. The Committee would definitely put down their opinion that it is a fallacy to think that a large number of inefficient cattle will yield more cowdung for manure than a smaller number of well-fed and efficient cattle. It is, therefore, in the interests of everybody concerned that, where the pressure of human population is the keenest, every step should be taken to utilize waste areas for supplying better cattle food and better fuel. The Committee feel that the latter would release farmyard manure and vegetable refuse to renew the fertility of the soil, and the cultivator living on the spot will be able to follow the directions of the Agriculture Department in getting out of the land a variety of crops that would in the end provide for him more balanced nutrition than is the case at present. The Committee, in short, would not look upon these waste areas in most of the villages as susceptible of exploitation as independent units. They are to be exploited in correlation to the whole village economy so as to restore the balance in that village economy.

As regards the few compact areas in Meerut, Unao and Rohilkhand, the district notes may be seen. It is possible to exploit some of these compact blocks which are at present lying waste in a manner so as to maintain a well-instructed colony of settlers under the control of the Waste Land Reclamation Board with its technical staff ready to give advice. The first step that would be taken would be planning out a scheme of afforestation, closure to grazing and starting a dairy farm and from this nucleus the transition to the agricultural life would be brought about—the pace to be set by the money available for reclaiming some of the mild alkali areas for purposes of growing food crops.

CHAPTER IV

SOIL CONSERVATION WITH SPECIAL REFERENCE TO THE CONTROL AND PREVENTION OF SOIL EROSION

It is generally known that as a result of soil erosion there are extensive waste and ravine lands in Agra, Muttra, Etawah and the adjoining districts. The ravines of the Jumna and the Chambal rivers form a practically compact mass, the extreme length of which is 70 miles and the width about 13 miles in the centre. It is estimated that in the Etawah District alone there are about 120,000 acres of ravine land and there are large ravine areas in Agra, Muttra, Jalaun and other districts. Although the area under ravines in the United

Provinces is not known, the total area of land in the province under ravines, rocky hills, river-sand, bare sand-dunes, etc., is 3,120,000 acres.

In a meeting held in February, 1935, of the Crops and Soils Wing of the Board of Agriculture and Animal Husbandry in India a reference was made to the systematized work done by the Forest Department in the United Provinces in the direction of reclamation of ravines by means of afforestation. The following is a résumé of the work already done by the department :

The work has been chiefly in the Jumna-Chambal tract of the Agra, Etawah and Jalaun Districts. The total area treated exceeds 15,000 acres, so that considerable experience has been gained and the following conclusions may be accepted as proved :

(i) Owing to unfavourable climatic conditions (drought, frost, etc.) and the existence of impermeable strata below ground (usually *kankar* pans), the creation of commercially profitable timber plantations is not possible. (ii) Erosion and rates of run-off of rain-water can, however, be greatly reduced, if not altogether checked, simply by control of grazing of domestic animals, in time, intensity, and kind of animals. Thus, by limiting grazing to one head of bovine cattle per acre and a severe limitation on the destructive goat, combined with rotational opening by blocks, e.g., one block open for 2 months and 2 blocks closed, or better still one block open for 2 months and 5 blocks closed, the natural vegetation which is Nature's own protection against erosion and floods, has a chance of springing up thickly, and this alone has proved most effective.

Simultaneously with checking of erosion, the rotational controlled grazing results in a considerable development of the better fodder grasses and hence in an appreciable increase of fodder production.

By control of grazing, combined with small *bunds*, on the flat lands above the ravines, further extension of erosion into the cultivated lands can very largely be stopped. It is now generally recognized and accepted that the appalling gully erosion in the Gangetic plain generally, and in the Jumna-Chambal area particularly, is due primarily to overgrazing which destroys the natural vegetative cover, and it can be cured only by limitation put on the grazing.

The high incidence of floods has brought this question of soil erosion very much to the fore. The evil has been with us like our poor relations for the last several hundred years and incalculable harm has been caused by the washing away of the fertile soil particles. The inroad on fertility by soil erosion was, however, little appreciated by the public until recently. For almost the first time in these provinces considerable attention was directed to the evils of soil erosion in the Inter-Provincial Flood Prevention Conference held recently at Lucknow

to devise ways and means for the control of floods in the United Provinces, Bihar and Bengal. The question of checking erosion and of reclaiming ravines occupies a place of honour. It would be desirable to take a bird's-eye view as to what has been done in other countries to stop erosion and turn the spent areas as they are called in Russia 'fruitful with vegetation.' We would like to give in very brief what is being done to check erosion in other parts of the world so far as that information is pertinent to the type of problems with which the Indian peasant in the United Provinces is familiar and without losing sight of the fact that the money available is limited.*

The general Fascist conception of society as an integral whole has now conferred an integral character on land reclamation. The aggregate of all the works required in any given sector—whether they cover land settlement, social measures, reconditioning of mountain land, the control of watercourses, drainage, irrigation, aqueducts, the breaking-up of new lands, the reconditioning and improvement of the soil, experimental work, road-making, the erection of villages, buildings, power stations, the laying of electric lines, etc.—all compose integral land reclamation.

Japan offers an example of a country with highly erodible soils and topography and torrential rainfall where erosion is effectively held in check by methods adopted regardless of cost and from a realization that the alternative to their adoption would be almost immediate national disaster. The danger from erosion lies not so much in the actual loss of soil from the steep mountain slopes as in the deposition of debris on the paddy fields and their consequent conversion into infertile areas. The Agriculture Department in Japan has spent up to ten times the value of the eroding land to control erosion; much of the outlay, however, must be regarded as having been expended in saving the valuable valley lands from deposition from above.

Erosion control is based on two principles—first, the establishment, of a based level of erosion for the drainage channel; and, secondly the artificial revegetation of the eroding surface when such measures are considered necessary. 'Erosion control—takes on the nature of a great game of chess. The forest engineer, after studying and mapping his eroding valley, locates and builds one or more check dams. This is his move. He then waits to see what the responses of the natural forces are. The check dam establishes a fixed base level of erosion for the thalweg above it. The slipping and sloughing side slopes may after five years come to an angle of repose, whereon vegetation will establish itself naturally. More likely this desired result will not

* Information on the position of soil erosion in the other parts of the world has been collected from 'Erosion and Soil Conservation' by G. V. Jacks and R. O. Whyte, Imperial Bureau of Soil Science, Tech. Comm. no. 36.

come so quickly. The response of the natural forces in their turn determines the forest engineer's next move, which may be another dam or two, or an increase of the height of the former dam, or the construction of side retaining walls. After another pause for observations, the next move is made, and so on until erosion is checkmated. The game takes on a lively interest. The operation of natural forces of sedimentation, plant succession and revegetation must be guided and used to best advantage to keep the costs of this expensive work down to the minimum and to practical proportions.' The construction of check dams or side walls, and of channel works has for its chief purpose the establishment of a base level of cutting or erosion by the stream. This stops the undercutting of slopes by the current of torrential waters. In some instances little more is needed, for the slope material comes to its angle of repose and vegetation naturally takes possession and produces the desired protective mantles. In other cases measures are necessary to fix the soil on slopes. No attempt is made to fix slopes at a steeper angle than slopes of the same material are held by the natural vegetation in the vicinity. No more is attempted than nature has already done in the region. These works of slope fixation vary in method and application. They are terracing and sod wall terraces, wattle-work networks, adapted and suited to the situation by the forest engineer in charge.

'A distinctive feature of the Japanese technique is the artificial production of a terrace of soil on steep slopes. The slope is graded down, for this purpose, to the tenable gradient under natural conditions. Small horizontal shelves or terraces are cut in the slope, usually on 5-foot contours. Slabs of grass sod are carried to the area and are placed on end or flat and layer on layer on this terrace. Behind the sod barriers dirt is pulled down from the slope'

In 1897 a Forestry Act was passed which made torrent regulations compulsory throughout the Empire. Article 14 of the Act provided for the setting aside of protection forests for the following purposes:

- (1) to prevent denudation of the soil ;
- (2) to prevent sand shifting ;
- (3) to provide protection against the devastation of floods, winds and tides ;
- (4) to prevent avalanches and rolling stones ;
- (5) to ensure a constant source of water-supply ;
- (6) to afford shelters for fish ;
- (7) to afford landmarks for navigation ;
- (8) to improve public health and sanitation ;
- (9) to maintain the scenic beauty of temples, shrines, noted places and historic sites.

In U. S. S. R. it is the policy of collectivization that has given impetus to the study of soil erosion by denudation and leaching.

Particular attention has been paid by the Novosil station to the 'brosovie zemli', the nearest English equivalent of which is 'spent lands'. Spent lands are badly eroded areas adjoining watercourses and occurring on the bottom third of eroding slopes. The former surface soil horizon has usually disappeared more or less completely, and the spent areas are interspersed with frequent hollows and gullies. The significance of the spent lands lies not so much in their uselessness as in their destructiveness. They act as foci from which erosion spreads, both in length and breadth, at an alarming rate. Lying at the bottom, and often on the steepest part of slopes, they receive the full destructive force of the run-off from above, the old gullies increase in size and produce new vertical denudation, destroying the vegetation, increasing the mean gradient of the upper slopes, and making the land less and less resistant to erosion. Furthermore, the abandonment of spent lands results in the cultivation of less suitable areas lying above them.

Owing to excessive erosion, the humus horizon of spent soils is very thin (normally 8—10 cm.) The soils, however, are far from 'dead.' From microbiological studies it has been shown that, under optimum moisture conditions, they develop a very rich bacterial flora and a somewhat less rich fungal flora. The principal need of the soil is for nitrogen, to which they respond in a quite remarkable degree 'levelling out the yield-depressing effect of a slope throughout its length.'

According to the report of the Palestine Royal Commission, 'the fact has to be faced that there are today no real forests in Palestine and that if there is one country in the world in which afforestation is desirable, that country is Palestine.'

The Commission does not doubt that in the aggregate there is a very large amount of land for afforestation but not for cultivation and in any case it strongly endorses the policy of :

- (1) afforestation of steep hillsides to prevent erosion,
- (2) the prevention of grazing on land fit for afforestation, and
- (3) where practicable, the establishment of village forests for the benefit of the neighbouring cultivators.

Considerable areas have been denuded of certain types of natural vegetation by fuel cutting ; with the increasing population in the towns and rural areas the question of fuel supplies becomes more acute from year to year. Fuel grounds are invariably grazing grounds as well. The forest cover of juniper has been destroyed, the surface soil washed away and the underlying limestone rock exposed

over the whole of one typical area. Serious erosion on grazing lands is also due to the unrestricted cutting of *Thymus capitata* for village and town fuel supplies and *Sanguisorba spinosa* for fuel and fence-making.

The usual measures adopted to decrease the velocity of surface run-off are (a) use of dry stone walls, (b) terracing, (c) strip cultivation, (d) reclamation of valleys by training and damming streams, (e) tree planting combined with cereal growing in the hills, and (f) irrigation with silt-laden flood waters. The dry stone wall method is the most general and effective method and is used in a number of different circumstances.

Apart from forestry and its relation to erosion control and the traditional measures of dry stone walling and terracing, the following measures are considered to be necessary to prevent abnormal erosion in Cyprus :

- (1) The reduction of sheep and goats in each village area to the numbers the village grazing grounds can normally support.
- (2) A change in the system of grazing from unorganized grazing to rotational grazing.
- (3) The provision of supplementary feed to grazing animals during the autumn months.
- (4) The reduction of the number of goats in the hills.
- (5) Prohibition of grazing animals on steep cultivated slopes.
- (6) The prevention of intensive 'thrumbi' (*Thymus capitata*) cutting on grazing grounds near towns and villages.
- (7) Tree planting in the plains and foot hills.
- (8) The planning of a drainage system in conformity with the erosion control methods.
- (9) Strip cropping on the contour where the donum value of crops does not justify the expense of terracing.
- (10) Checking the rate of flow of the streams and torrents in the mountains and hills by constructing check dams and by afforestation.

Mythology has ever clothed striking acts of economic strategy with the resplendent garb of divine intervention. Siva—the radiant path-finder (as opposed to his mood as an irate destroyer) is represented as loosening his matted locks and receiving the waters of the Ganges as they debouch out of the rocky ramparts of the Himalayas so that the poor earth on the plains might not sink and be washed away. The matted locks are tree-covered slopes of hills which regulate and check the onrush of waters and train them to flow into regular channels. We must again become alive to the evils of erosion and

afforest areas which are ravines so as to train the waters that flow through them.

According to Dr. R. M. Gorrie of the Punjab : 'The human population of India is increasing at the rate about three millions per annum. Much of this increase is occurring in the tracts where nature, in the first place, provided easy conditions for human settlements, namely, a rainfall not too heavy for the ordinary farm crops and natural grasslands, in which cattle thrive and remain healthy. Within the heavy rainfall areas further east, the regrowth of dense tropical jungle and conditions inimical for live-stock have discouraged dense settlement. Therefore much of the weight of this increasing population is falling upon the *tension belt* where grassland can persist only under reasonable treatment, and, if once destroyed, cannot reinstate itself as easily as it can under a slightly heavier or better distributed rainfall. Hence over very large tracts of country, natural grasslands have already disappeared and village live-stock are dependent upon bush and tree growth for their day-to-day existence.'

In many parts of India, indeed, the high cost of loans and the impossibility of getting any immediate economic return from reclaiming very poor and badly eroded land is seriously impeding soil conservation work. 'Self-help' projects on a community basis in the villages appear to be the most hopeful solution for farm lands.

Encouragement of grass and closure to grazing over as wide an area as possible are the most hopeful antidotes to sheet erosion, though they will not prevent it entirely. The chief obstacle in the Punjab is the thousands of Siwalik peasants who demand the use of the land and consistently over-graze it. A closure effected by legislation in 1902 has brought great benefits to some villagers, who now make handsome profits from the sale of surplus cut grass, and it is hoped that this example will act as an educative influence. If once grass can be established, bush and forest will follow and completely check erosion. Closure, stall-feeding and a proper system of pasture management, including manuring and green manuring, are the only practical means of starting to reclaim both the hill lands and the devastated plains which are more and more needed for the support of the increasing population.

The Punjab Government has made a beginning towards introducing a sound land-utilization policy based on fodder production, but progress must necessarily be slow, since it involves a profound change in the whole life of the grazing communities. Three forest officers have been allocated in the worst eroded districts to obtain rotational grazing closures (with the consent of the villagers), to reserve hay fields and to institute general-erosion-and torrent-control measures, as required by the circumstances. Constructive work, however, can only be done on a self-help basis of free labour, because the Government cannot afford to undertake it. Gorrie suggests that

fodder production for local live-stock could be stimulated by the following measures :

(a) Rotational closures of grazing lands belonging either to individuals, village communities or the Government. Much Government land is so heavily burdened with rights as to be uncontrollable except by agreement.

(b) Partition of *shamilat*, by allocating the common grazing land to individuals to cultivate or conserve for their own animals ; this has been extraordinarily successful where there is a real scarcity of cultivated land.

(c) Panchayat or village committee management ; in certain parts the delegation has been most beneficial.

(d) Intensive improvement of natural grasslands, including 'gully-plugging,' to stop active erosion and the application of the principle of wattbundhi or contour ridging, so far applied only to farm crops, to the more gently sloping grasslands.

(e) Development of the tree-fodder supply by distributing transplants of suitable tree species. The use of tree loppings for fodder is a feature of much Indian animal husbandry.

(f) Development of the use of green fodder crops and silage. In the poorer parts land cannot be spared for any crop that does not produce human food.

(g) Research on the correct grazing incidence for local types of bush and grass ; given stall-feeding for the two hottest and driest months in the year and closure during the monsoon growing period, this incidence could actually be fairly high for the remaining months without causing excessive denudation.

(h) Restriction of immigrants and 'non-right-holders' live-stock—a thorny problem.

(i) Reduction of local herds by encouraging castration of scrub bulls, and by propaganda and demonstration of 'fewer and better cattle.' The change to grass-cutting would in itself be helpful because nobody will cut grass for animals which give no return in work or milk.

A plot of 40 acres area was divided into four paddocks. Cattle was introduced and after grazing each as closely as possible before moving on to the next, it was possible, after five years, to maintain 20 cows on the area throughout the year. Good grasses had replaced the inferior ones and, in spite of the very heavy grazing, natural tree regeneration had begun and erosion had been checked. The land was in a condition in which it could be utilized at will, either for forest or pasture purposes.

In Bombay areas between low hills and scrub jungle have been found near Poona to be subjected to excessive erosion.

General Smuts in one of his incisive writings uttered a timely warning, 'Erosion is the biggest problem confronting the country bigger than politics.' If the land in South Africa is rendered less fertile, any policy calculated to sustain white dominance would be frustrated. In spite of men-made laws, nature would revenge itself and the black races would assert their supremacy as before. This in substance is the warning that he has uttered. We in India have not the problem that confronted our forebears when they had to fight the *Dasyus* on the onward march of the Aryan conquest. But in some parts of the United Provinces we have reached a stage in which both the spectacular erosion known as *behar* formation (known as gully formation in England and Donga formation in South Africa) and sheet erosion have caused a loss of fertile particles, which unless, stopped at the right moment and in a comprehensive manner would bring about extinction of civilized life for people living on the denuded soil.

There is an old Hindi agricultural saying :

'San gahno ban begero jondher medhak phal.'

(Sow hemp close, cotton apart and millets at a distance of a
frog leap)

which refers to the practice of sowing of crops with clear spacing between two rows, the idea being to give the plant full scope for branching out. It is forgotten, however, that a succession of such crops leaves the intermediate space of the soil exposed to an insidious action of erosion. In America they have noticed that in cornbelts unless a leguminous crop does not intervene, the soil on account of the spacing between rows of maize crops acquires a tendency to erodibility. What is needed is a sound system of rotation with the object of preserving soil structure, providing a proper soil cover and in not allowing the granular character to disappear. We have areas in parts of Fyzabad, Jaunpur and Azamgarh Districts, where considerable damage has been caused by this sheet erosion, with the result that at present on account of the quiet and persistent havoc caused by unregulated flow of water no vegetation except stunted grass is noticeable on these areas.

One of the most common methods of reducing run-off velocity is to break a slope by terracing. Damming watercourses and listing are other purely mechanical ways of checking run-off, bolstering up the weakened fabric of the soil and cementing it anew with moisture. As water flows down a slope, it accelerates under the force of gravity, its erosive power increasing as the square of its velocity (i.e. doubling the velocity quadruples the erosive power). By throwing a terrace or dam across the direction of flow, run-off water is held up, soil carried in suspension is deposited, and by skilful management any excess of water not

absorbed by the soil may be turned to some useful purpose such as irrigating low-lying or watering stock. At worst the accumulated water debouches over the terrace or bank, possibly destroying it in the process, and continues down the slope with lower velocity and erosive power than if its progress had been unimpeded. Terracing is the older known method of stopping erosion. What is needed here is *bunding* up the area, impounding the water and give that water every chance of soaking through and opening out the soil. The *bunding* should be of the nature of contour *bunding*—where the slope is considerable terracing should be of the nature of contour terracing as opposed to flat bench terracing. The design of terraces and dams is becoming a specialized engineering job in which local characteristics of climate, topography, geology, soils and vegetation have to be taken into account. Since the object of terraces is to check as far as possible the flow of run-off under gravity, they are most effective when built on one level, i.e., following the contours of the lands. A picture of a field terraced on the contour looks rather like an orographical map, in which the contour lines twist and turn and double back on themselves according to the lie of the land.

In areas threatened with sheet erosion but which at present bear reasonable crops, strip cropping has been found most efficacious. Strip cropping, i.e., sowing close-growing and clean-tilled crops in alternate, narrow strips laid out across a slope on contour lines. The close-growing crops absorb all the rain that falls on them and prevent erosion and, at the same time, catch any soil and water carried down from the clean-tilled strips.

World experience has taught us the dangers of over-stocking. In India the danger is on account of the religious feeling for the cow, which is venerated in the abstract and neglected in every-day practice. But the elimination of the bovine species is, in most cases, not feasible. It can only be after a lapse of considerable period that the present quantity will be replaced by quality and there would be reduction in numbers. But the one animal that has played considerable havoc is the goat. In 1932 a communal storm burst in Kashmir engineered by *bakarwals*. It was a protest against the raising of grazing dues and exclusion of goats from grazing. The havoc caused by these animals in denuding slopes of all vegetation in Hoshiarpur District resulting in *chho* formation had sounded a note of warning to the Kashmir Government and they had taken this wise step. Vested interest, however, asserted itself under the guise of communalism. The *bakarwal* was a Muslim and the said regulation was stigmatised as anti-Muslim regulation.

In the riverain area of the United Provinces the goat has been both the robber of the fertility of the soil and, in most cases, it has been left the sole occupant of the soil now reduced to ravines where

it ekes out a precarious living by climbing steep ravine sides for grazing out any little vegetation that is holding the soil together. This explains the forester's feeling against the goat and partiality for the sheep. The former uproots tiny vegetative shoots sticking out from steep hill sides and prevents vegetation from establishing itself and acting as binder of the earth as against the run-off of water. If the goat merely grazed the grass of the ground, it would not cause so much damage, but it is let loose in the areas where no other animal can find anything to sustain itself. The Gujrati proverb is that the camel would not eat *ak* tree and the goat eats out everything but the *kankar*. There is an interesting village story related in connexion with the havoc caused by the goat. An ancient soil conserver condemned the expansion of the stock of goats. The period must have marked the transition from the pastoral to the agricultural stage. The goat fearing that he was being exterminated because he was being eaten by every community went with a petition to Brahma that its meat should be declared unlawful for some community. Brahma, however, turned it out and declared that his own mouth was watering on looking at the goat. The moral is that agricultural economy is not possible without eliminating the goat economy. We are told that in certain parts of the United Provinces the goat—as to a neapolitan—is the poor man's cow. If he is serving that purpose, let its grazing be controlled in area and numbers, and it should not be allowed to uproot tiny shoots springing out in eroded areas, which are trying to maintain a foothold and bind the soil so that further gully formation may not take place.

Goats may be good milking machines, if stall-fed ; but in ravine areas they constitute 'the machine-guns of the forests' and destroy everything.

The best cure for the ravages of ravines is contour trenching and gully plugging. The Committee feel that gully plugging helps in delaying the onward march of the silt-laden flood and holds back part of its load of detritus and soil wash until plant growth can fix it firmly. The Committee commend the planting of *japlota* and *thuer* (prickly-pear), as is done in the Sohan valley in the Hoshiarpur District. In stony gullies agave has proved useful ; in damper *nalas* some kind of willow or cane and bamboo have proved useful ; in wider sandy torrent bed the Committee recommend what Dr. Gorrie has done in the Punjab—sow *nara* seed and *banha*. *Bhabbar* grass will also promptly take root. For stopping torrential action of water in gullied areas a hedge of *banha* (*Vitex negundo*) will be very useful.

The Committee recommend that on waste land areas where grass has sprung up on account of their closure to grazing, steps should be taken to get the grass cut because until the area is really reclaimed there is little possibility of that grass surviving desiccation that follows

a rainy season. It may be found useful, if technical advice so directs, to allow the grass to be ploughed in the area so as to enrich the area and loosen it so that it may be in a position to absorb better moisture and produce a better crop of grass next year.

The main conclusions from experiments on improvement of fodder and grazing and the reclamation of the Jumna and Chambal *behar* or ravine areas are :

(i) Closure to grazing enormously improves the quality and quantity of fodder grasses and indigenous trees and shrubs, encourages their natural regeneration and effectively prevents soil erosion and the extension of ravines. Ravine management and prevention of extension of erosion in ravines are simply questions of control of grazing and improvement and preservation of grasses.

(ii) Whenever a protected area is opened to continuous or unrestricted grazing, the reversion of the area to its original state with serious deterioration or almost complete disappearance of the useful fodder grasses and indigenous shrubs and trees is very rapid.

(iii) Closure beyond a certain period does not help in the further improvement of the grasses.

(iv) Cutting of grasses twice or thrice in the year gives a greater yield than a single cutting at the end of the grazing season.

(v) If the grasses are not cut or are not allowed to be grazed, but are allowed to rot, the quantity and quality of the grasses deteriorate within a few years.

(vi) Experience goes to show that the maximum permissible incidence is two acres per cow.

(vii) Appreciable results from the treatment applied to a grazed area may be obtained in from one to five years according to the initial condition of the area concerned.

The Chief Conservator of Forests is of opinion that *bund*-making is not necessary for establishing grasses on the *behar* (ravine) areas of the Jumna and the Chambal. *Bunding* would, however, prove useful and wherever it is proposed to plant timber in pockets of good soil (without any *kankar* pan) the experience of the Forest Department is that trees would flourish well in the portions that would be reclaimed by the deposit of silt behind the *bunds*.

There are plenty of areas on the right high bank of the river Ganges, known as '*khola*' areas situated in Meerut, Muzaffarnagar, Saharanpur Bulandshahr, etc. Here also the problem of reclamation is in the main similar to that of the ravine or *behar* areas referred to above. The Forest Department hope eventually to be in a position to afforest

this area with valuable fuel and timber trees, which would provide fuel for big cities like Meerut and Delhi, and release the cowdung that is at present being burnt.

It is interesting to note here that according to a rough computation no less than 5 million tons of cowdung is burnt annually in this province. If we have sufficient fuel resources, this cowdung could be reclaimed for its natural usage, i.e., for manurial purposes. By the afforestation of the *khola* area and establishing trees on strips just on the top edges at the head of the *khola* region, we shall be in a position effectively to put a stop to the present ravine formation, that is, eating back insidiously into the vitals of the fertile fields. In this way, the denudation of valuable soil particles would also be stopped.

It is possible to grow valuable timber in the *khola* area while the Forest Department have not been in a position to grow timber in the *behar* area of the Jumna and Chambal. This is due to the *khola* region being free from any *kankar* pan whereas in the *behar* area a *kankar* pan usually occurs at a depth of about 4 feet, from the surface which prevents the growth of deep-rooted trees.

Closely allied to the problem of land erosion is the question of checking the excessive run-off with special reference to the diminution of the crest of heavy floods, as is generally experienced in the eastern parts of the province. Where run-off water is excessive, it might result in sheet erosion, that is, erosion taking place slowly and evenly over a large area, and in contrast to gully erosion, which is much more localized and which in time produces ravines. Also it might cause normal supplies of underground water reservoirs to be depleted, and the water-table may become too low for practical use.

Unfortunately, very little quantitative data are available in the United Provinces regarding the calculation of run-off from the different types of catchments. As a matter of fact, reliable run-off figures are not available for any part of India. From measurements made during one complete rainy season in Bundelkhand by the Irrigation Department, it has been found that with vegetation on the land the run-off is only 25 per cent. of the total volume of rain-water; whereas, under barren conditions the run-off amounts to as much as 75 per cent. of the total volume of rain-water. Dr. Gorrie has recently furnished some interesting figures for the run-off in certain forest plots at Nurpur in Kangra District in the Punjab.

The results obtained by him are as follows :

	Grass 80 per cent. cover	Grass and shrubs 90 per cent. cover	Bare soil grass clipped every 3 days
Percentage of rain which ran off— Out of total of 46 inches on 32 wet days during July-October, 1937	7 per cent. . .	5 per cent. . .	25 per cent.

Much further quantitative work on the run-off under different cover crops in relation to topography of the land and the erodibility of different soils must be carried out before it could be possible to take suitable preventive measures.

Regarding the question of the effect of reclamation of alkali land on floods, the Committee are of opinion that the growth of vegetation on the soil undoubtedly slows down the run-off and reduces the peak of the flood. While undoubtedly the capacity of the soil to absorb water is increased by any process of reclamation this will only affect floods where a large part of the water absorbed can be passed through the soil into the ground water. Excessive leaching is usually not possible in the type of alkali land we have in the United Provinces. Even were it fully reclaimed, the soil could not store any large quantity of water in the upper layer. The capillary capacity of the soil is rarely more than one inch of water per foot of depth of soil. Taking into consideration these facts, the Committee feel that reclamation of alkali land in the United Provinces for cultivation is not likely to have more than an inconsiderable flattening effect on the crest of the floods. The obstruction, however, that a grass-covered soil offers to the passage of water is considerable.

Afforestation besides providing for interception of rain and its re-evaporation before it reaches the ground plays a very important part in giving protection against floods on account of the forest litter which had a high water-holding capacity. It is generally assumed that the water-holding capacity of forest litter is about 8 times more than that of the soil. The researches carried out in recent years with some Dutch forest soils prove that forest litter is more effective on the finer textured soils in which the litter continues to function as a preventive of run-off even after it was completely saturated. Apart from its water-retaining capacity, the litter fulfils a further important function, that of preventing the silting up of the soil pore space by the washing down of the finer components of the soil.

The data so far available enable the Committee to recommend that as suitable measures for flood prevention, afforestation is infinitely more effective than turning the area into a grass preserve. The emphasis here is not so much on making the soil permeable so that water as it passes may be absorbed and the underground reservoir replenished, but to put obstacles in the path of water as it passes in its headlong course carrying with it the top particles of fertile soil. It is a kind of obstacle race that the water has to face and its velocity as well as its mass action are considerably diminished if the land over which the water passes has a grass cover and is littered with leaves and twigs, which are the inevitable concomitant in an effectively afforested area.

The Committee have taken into consideration the questionnaire addressed to them by Government as to the action to be followed to reduce the crest and the erosive action of floods. There are three zones to be considered :

- (1) the hills of Kumaun,
- (2) the ravines, and
- (3) the waste lands in general, and in Fyzabad, Azamgarh, Jaunpur and Ballia in particular.

As regards (1), the Committee's recommendations are that no effort should be spared to prevent deforestation of the existing 2,000 square miles of Class I forests in the Kumaun hills.

As regards (2), the Committee endorse the opinion of the Chief Conservator of Forests that control of grazing in ravine areas will ensure better growth of natural vegetation, which would tend to check further gully formation and erosion and thereby reduce the crest of the floods and the run-off.

As regards (3), waste lands in general, the Committee have submitted their proposals for their better utilization in this report. They wish to emphasise that with increased vegetation on these waste land areas, there is bound to be more absorption of rain-water and consequent reduction of the crest of the floods in periods of heavy rainfall.

CHAPTER V

PREVENTION OF LAND DETERIORATION

The Committee strongly feel that in the treatment of agriculture the centre of gravity has remained too long stationary at the fiscal point. We have encouraged the growth of crops which would yield the largest revenue to the State, and, along with the State, to its partner in agricultural wealth—the cultivator. The State has, no doubt, invested capital in the provision of canals and in flood prevention schemes. But it is only lately, however, that the centre of gravity has shifted from the fiscal to the much more important aspect of the conservation of soil fertility. The cultivator thrown on the screen of the future is now being envisaged in his own interest as a wealth-producing factor and a consumer of goods produced by the rest of the community. Everything is concentrated now on making him the inheritor of a more tractable and better responsive instrument of wealth-production, and an effort is being made to develop his personality so that the agent of the future will be an economically more efficient agent and the *milieu* in which he will be working will be economically less intractable and more responsive to his well-directed efforts. The Committee feel that in the emphasis that is put on this

change of angle of vision the strenuous and systematized efforts made by the present Government need a more dispassionate and sympathetic appreciation.

We have realized that a particular soil monolith is a matter of historic growth, that it is a dynamic unity, living and growing. We have suddenly become awake to the fact that other departments are to be yoked to the service of agriculture so that it might progress at an even keel. The most important science that has come with open arms to its assistance is forestry which has left the seclusion of the hills and come down to the plains to serve as the hand-maiden to agriculture. We have realized what the value of forestry has been for the conservancy of soils in the plains, for serving as a wind-screen to prevent the transportation of particles of fertile soil and for putting a brake on the incidence of floods and soil erosion. Bio-Chemistry has emphasised the essentially hive-like character of a normal soil monolith. Micro-organisms are busy building up constituents of food to sustain the surface vegetation, which on its side has sent down and out its foragers in the shape of rootlets and root-hairs in search of this assimilable food. If that vegetation is to have the optimum chances of growth, be it a herb, a shrub, or a tree, it must demand the maintenance of the soil life at its best. Agronomists, therefore, are never tired of reiterating the necessity of co-operative work on the field, of the departments that supply water on the field, of the departments that supply water for irrigation ; of the Forest Department that conserves the soil and of the Agriculture Department that arranges for the return of the waste products to the land so that the soil texture with its humus may at least remain in tact, if not show progressive signs of improvement. In taking up this question, therefore, the Committee has concentrated its attention on matters, other than purely technical matters on which a lot of information is available about the reclamation of alkali or saline areas. The problem to which it has addressed itself is a more prosaic problem of how to make the land, which is available in every village, better suited for growing crops (food crops and commercial crops), better grass, better fodder and more fuel.

The Committee in Chapter IV have dealt with the havoc caused by soil erosion and how best to convert the barren ravine areas ' that wasting asset,' by engineering and silvicultural methods, into growing capital. It may be that the absence of funds might impede the progress of this work, but the Committee would be failing in its duty if it did not emphasise the more prosaic fact that, in order to assure the continuance of the present income from the produce of land, we have to take those steps in the direction of all-round conservancy which will not only reclaim some of the infertile lands and make them fertile, but prevent existing fertile areas from slipping down the precipice of infertility. We are most concerned in the intensively cultivated areas

in the eastern districts of the province to grow more cattle food either in the shape of fodder crops or grass. On the side of the Jumna River we have our internal enemy, the ravine, that, like the tubercular bacillus, is eating into the fertile soils. We have signs in areas bordering the Punjab of water level going down and sub-soil water becoming brackish and the incipient creeping in of desert conditions. In the interior of the province where the cultivation is intensive and pressure on land carries a population of more than 800 per square mile, the areas that are available for manipulation through improved agriculture are extremely limited. By the continual packing of soil particles with the passage of cattle hoofs, this area becomes imperviable to moisture, and the result is that on the one hand salts are coming up by capillary action and rendering the top layers more saline, and on the other the little grass that maintained a precarious foothold and found air and water in the soil is being grazed out of existence. We shall soon be left sandy plains bearing no vegetation and incapable of retaining and absorbing any moisture which is the result of natural precipitation. With the coming in of commercial crops the soil is not getting back the full quantum of organic matter which is necessary for its healthy life. The agronomist has emphasised the necessity for keeping the soil alive. We are therefore to provide ways and means by which the vigour of the soil can be kept up at its optimum, so that the man—the manipulator—will find a tractable medium and the State, the reaper of the harvest, may continue to get its share of the wealth uninterrupted. Mother earth has to be milked, but the udders are never to run dry, and therefore she has to be fed and kept at optimum health. We have always looked upon agriculture as a mode of life and not as an industry in which the maximization of wealth is possible without undermining the sources of production. The Committee feel that the Indian has lived in symbiotic existence with land and has always looked upon land as a living thing not to be too much exploited. His customary fallows gave land the much needed rest which in his present greed as an exploiter he is now grudging. In the past the wisdom of ages that guided him kept him on the path of conservative use of land. Tulsi Das in describing the ardour of a devotee has compared him with the agriculturist, who in spite of tardy return has continued his labour on the soil unimpeded. The words of a recent Italian writer on 'Soil Integration,' which Mussolini has made the pivot of his policy, are pertinent. He says :

' It is therefore necessary to elucidate the value which should be given to the word " agriculture." It should not be understood as merely denoting the possibility of obtaining products from the soil. That has always been and always will be in all ages and all countries, for all and always have eaten and will eat. But we must give agriculture its full, profound, human significance ; we must consider it as the most complete and complex manifes-

tation of human activity and of humanism, the art through which the intimate spirit of a people expressed itself, which evolves and assumes aspects and importance of vastly varying kind according to the quality of the people exercising it. And it is in the exercise of this activity that nation perfects its qualities.'

It is this spirit of improving the *tout ensemble* that constitutes the cultivator's environment that informs the measures taken by the present Ministry and making the rural reconstruction a reality instead of a far distant dream.

The Chairman and the Secretary saw in detail during their tour in the Punjab the steps taken by the Irrigation Department in that province for preventing land deterioration on account of accumulation of sodium salts in the soil profile in areas where the water-table is high. The Sheikhpura Division of the Upper Chenab Circle may be quoted as an example. From records available it has been found that the water-table in the deteriorated land of this area is within 6 feet of the surface. Under these conditions of high water-table and the absence of rain for long periods, the tendency has been for the salts originally distributed throughout the soil, to accumulate in the surface zone thus rendering the soils alkaline. Owing to the general presence of small quantities of sodium salts in the Punjab soils (as is usually the case in the United Provinces) a slow deterioration of soil is also taking place. According to the Punjab experts the effect of this slow deterioration is only apparent over a period of years, and hence, is likely to escape notice, unless a careful and periodical survey of the soils or crops is made, of which the soil survey method is taken to be the most reliable. From the investigation carried out in the Punjab, it appears that the problem of preventing land deterioration reduces itself to the prevention of sodium entering the exchange-complex of the soil.

This is accomplished in practice by the following methods :

(a) By a suitable crop rotation in which rice is used as the agent for decomposing the sodium clay.

(b) Application of gypsum which introduces calcium ions in solution.

Mr. James Thorp in his suggestive study of Geography of the soils of China writes :

'In establishing new irrigation projects in a semi-arid region, therefore, the first matter to be taken into consideration is that of drainage no matter how well the soil drained is under natural conditions.'

We have already indicated above that both in the Punjab and Sind it was the introduction of canal irrigation which first brought about an outcrop of efflorescence. When canal irrigation was first introduced in the Meerut Division (Aligarh was part of the Meerut Division in those days) insufficient care was taken to provide drainage cuts, with the

result that the internal water economy was interfered with and water-logging followed with rise in the water-table and appearance of salts on the surface. In many cases salts which were diffused came to be concentrated. The corrective for both has been found to be maintenance of soil texture in a sufficiently porous condition so that water coming from above is absorbed by the soil. We have to learn by the lessons of the Mat Branch in Bulandshahr and Aligarh Districts, and the damage to the soil caused by canal irrigation in Meerut, particularly near Ghaziabad. In all these areas water-logging ensued on account of the insufficiency of the drainage channels. The Irrigation Department have assured us that for every 3 miles of canal they have now 2 miles of drainage cuts. The canals themselves are now utilized in the rainy season as drainage channels for sub-soil water to be drained out. We have learnt by experience that running the canal all the year round or raising the bed for ensuring sufficient head of water for working hydro-electric schemes had led to interference in drainage and increase in seepage and consequent production of water-logging, specially in the areas round about Sumera in the Koil Tahsil of the Aligarh District.

Whenever canals are introduced in areas which are only accustomed to the economy of irrigation from wells, a great deal of forethought is necessary as to what the future crop rotation should be. When an area is irrigated from wells, there is little danger of disturbance in the salt zones of the soil. When the soil is subjected to the regime of canal irrigation, which ought to help in keeping the injurious salts at a sufficiently low level, there is great danger of these salts coming to the top in periods of fallow, when no irrigation is available during periods of fallow. The lesson to be learnt from salt-infested areas of the Punjab is that we should grow crops which require heavy watering so that the salts could be driven down to the sub-soil level. We have received complaints that soils are rendered infertile by over-irrigation. (This over-irrigation is the cultivator's provision against the vagaries of the Canal Department in the supply of irrigation water at proper times. If the time-table is adhered to with special reference to water requirements, there would be little danger of over-irrigation. In areas which are irrigated from tube-wells the complaint of over-irrigation is not forthcoming. It is not because water had to be paid there according to the volume, but because there is little danger of water not being forthcoming when the crop requires it.

The Chairman made a tour of inspection in the month of July, 1939, of tahsils Koil and Iglas in the Aligarh District. The portions lying on both sides of the main Ganges Canal from Sumera Fall up to Barauli were specially inspected. This portion lies in the northern part of tahsil Koil. The water of the Ganges Canal was raised on this line by about 5 feet for the purposes of generating power for the Hydro-electric station at Sumera. There are about ten villages which lie

on either side of the canal in this portion. They were already low and *reh*-infested, but the raising of the water made them worse inasmuch as *reh* considerably increased during the 4 or 5 years after the raising of canal water, and cultivation and vegetation were destroyed owing to seepage and water-logging. *Reh* either appears over extensive areas, rendering uniform tracts unculturable or in patches inside the cultivated areas. The Chairman made a detailed inspection of village Bajgarhi, which shows comparatively greater signs of deterioration. He also saw a portion of that village where an attempt has been made at afforestation of *usar* land by planting *babul* trees.

A photograph of this portion is attached. *Babul* was planted several years ago as an experimental measure with the advice of the Forest Department and although it seems that the place is rather neglected and no further attempt seems to have been made to extend the experiment on scientific lines, yet it was obvious that the land had improved and was capable of afforestation. Thakur Raj Kumar Singh of Barauli, a local *rais*, who takes interest in reclamation of *usar* land was present. Speaking from experience this gentleman stated that if *usar* land in this part of the country is flooded with water and protected from grazing, it grows grass in three stages. The first stage was the long acicular grass that does not grow high but creeps on the ground. This kind of grass grows copiously after rains but is liable to be destroyed by the hoofs of animals. The second stage was a long thin grass tufted at the top, and the third stage was a long thin grass with leaves growing on the stems laterally. The grass never becomes nutritious for the animals, but if allowed to stand on the soil, adds to the organic matter content of the soil.

As regards seepage, Mr. Lewis, Executive Engineer, was of opinion that there was sufficient siltage on the berms now and lateral percolation had stopped. The Settlement Officer supported the view and said that he did not see any water in the parallel seepage drain in the winter of 1937-38.

A plot of land in village Barauli where Thakur Raj Kumar Singh has made an attempt to reclaim *usar* was also inspected. The method employed consisted mainly of impounding rain-water and driving injurious salts to lower levels. The experiment shows every promise of success.

The Chairman also inspected parts of lands on either side of the Hathras Branch, which are supposed to be the worst for seepage on that line. Looking from Gandauli Inspection House up to Jahtauli, seepage was found on both sides of the canal. The land was very bad between Gursena and Jahtauli. On the right bank there was *usar* about which the villagers said that the land had gone out of cultivation during the course of the last 3 or 4 years. The canal bank has been widened in this part with the result that the side silt berms having not

yet established themselves seepage has continued. A photograph of a typical water-logged field in village Jahtauli is reproduced in Appendix IV (a). According to Mr. Bhargava, Executive Engineer, it is hoped that this defect will disappear in a few years. There were no drainage cuts made by the Canal Department. A line of sand ridges runs parallel to the canal on the left side. The Karwan Nadi flows alongside the canal at a distance of about 2 miles on the right side. There is over-drained country on the right side full of *usar* possibly as a result of sheet erosion, the land sloping towards the Karwan Nadi. The drainage on the left side is stopped by the canal bank on one side and sand ridges on the other. The defect in land here seemed mainly to be due to the high canal bank which obstructs the drainage and also contribute to *usar* formation on account of seepage.

The trees grown on either side of the Upper Ganges Canal were *shisham*, *neem*, *jaman* and *babul*. Afforestation was under the control of the Forest Department and the trees in general looked flourishing. *Babul* plantation showed luxuriant growth. On the Hathras Branch the trees were planted by the Canal Department themselves. *Babul* was observed even in the water-logged parts. The trees did not present a very satisfactory appearance.

We have already dealt with the question of erosion of the soil of what one might call the spectacular variety—gully erosion, and how to stop it; but there is a method of erosion more dangerous because of its insidious character, namely, sheet erosion.

This form of erosion goes on at almost an imperceptible pace and which generally escapes attention. It is only when the damage is far advanced that the full gravity of the situation is realized. In most cases it is brought about by excessive run-off over gently sloping land devoid of vegetation. In the eastern districts, large stretches of *usar* that we now come across are undoubtedly the cumulative effect of sheet erosion to which that tract has been subjected through hundreds of years. As a result of sheet erosion the surface particles constituting the most fertile part of the soil get washed away and what remains subsequently is the comparatively infertile portion of the soil which formed the sub-soil zone of the original profile. Unless effective preventive measures are adopted well in time it is certainly a very difficult task to repair the damage once caused by erosion of this form.

In this connexion the efforts of the Punjab Government towards building up a sound land utilization policy based on fodder production are indeed very commendable. The methods followed in that province have already been described in pages 87 and 88.

At present glaring cases of erosion are not rare in the Kumaun and Garhwal hills where in some localities steep hill slopes are being ruthlessly deforested to make room for commercial orchards or for growing of crops like potatoes. The Committee strongly feel that the statutory authority must enforce a condition precedent to leasing out of these areas (specially when the slope is greater than 50 degrees)

that terracing should be insisted on according to approved methods. This should apply more rigidly than at present to all *Nayabad* grants made in the hills ; otherwise, there will be a danger of losing valuable soil particles and rendering future growth of vegetation difficult.

When the economy of the village was more or less self-contained, the agriculturist knew by past practice what it was to allow rest to land so that it may recuperate its powers through, as it is now known, bacteriological agencies working at their optimum in the soil. On account of the coming in of money economy and the opening up of prospects of growing commercial crops on a big scale as a result of introduction of canal or tube-well irrigation, the cultivator is, practically speaking, subjecting land to butchering. Not only is the land allowed very little rest but also no effort is made to return sufficient amount of nutrients necessary for plant growth. Wherever sugarcane is cultivated no part of the plant is returned in any shape to the soil. No effort is generally made on a large scale to put the area under a leguminous crop to be ploughed in green so as to add to the organic matter and nitrogen in the soil. Neither is any effort made to supply organic manure like farmyard manure or compost in adequate quantities.

The Gorakhpur Agricultural Farm shows an average production of 700 to 800 maunds of sugarcane per acre with juice content up to 62 to 66 per cent. and recovery of sugar up to 9 to 10 per cent. It is admitted that the area on the Government Farm is given optimum dose of manure in the shape of 60 lb. of nitrogen per acre brought about by ploughing of green *sanaï* supplemented by 40—50 lb. nitrogen in the form of manure mixture consisting of sulphate of ammonia and oil cakes like castor cake, rape cake or groundnut cake. It also gets maximum number of waterings up to six irrigations during the growing season, but it should not be forgotten that the soil is cultivated with care before sugarcane is sown and during the process of the growth of the crop. The produce on the field of the average cultivator seldom exceeds 300 maunds per acre and yet both his soil on which the sugarcane grows and his crop are showing signs of deterioration. The seed which he uses is not free from disease because of insufficient care being taken in selecting the right type of healthy stock.

An intensive campaign is necessary to indoctrinate the cultivator of sugarcane in eastern districts that he is bringing about his own ruin and turning arable land into *usar* by his intensive cropping and failure to put back into the soil every bit of the litter, urine-soaked earth, cattle-dung and other cellulose matter that he can lay his hand on—all turned into good compost for manuring the soil, which is essential for successful growth of sugarcane and provides optimum conditions for the activity of the useful nitrogen fixing and nitrifying micro-organisms of the soil.

Wherever there are Sugarcane Marketing Boards it is necessary for a Better-Living Society to be constituted and empowered to lay

down by-laws by which if there is any unauthorized departure from a prescribed rotation of crops, the cultivator could be penalized. The local Statutory Authority must take up this question in a systematic manner. Scientific guidance must take the place of the wisdom of the past, the full import of which is now practically lost and the present short-sighted greed of the cultivator should not be allowed to work havoc without being checked at the psychological moment. The old adage put the unwisdom of sowing sugarcane in a field which had just yielded the crop.

“*Bari men bari kare, kare ikh mex ikh*
We nar mohi janyaye jo sune parai sikh.”

(If you grow cotton after cotton and sugarcane after sugarcane then you suffer ruin as one who follows another's advice in preference to exercising his own judgment.)

From a self-contained economy the cultivator has switched his destiny on the international trade. He produces what would pay him most—based on short-range calculation instead of cultivating what the soil would be able to bear with the least damage to itself. The policy of the Agricultural Department has been one of *laisse-faire* and has not interfered with this tendency of short-sighted maximizing of money prices from the products of land, which leaves the tenant exposed to the vagaries of foreign market, while at home he has to meet a steady drain on his slender income for the purchase of food grain for his maintenance.

Insufficient attention to the type of the manures to be used is another vital cause of land deterioration. Agronomists have found that Indian soils generally lack in organic matter. No scheme of supplying manures should, therefore, be approved which neglects this important consideration in the nature and total quantity of manure added to the soil. Every effort is to be made to build up compost heaps on correct lines and conserving farmyard manure specially in a manner which without sacrificing the convenience of the cultivator would ensure the raising of the fertility to the highest possible level. The Agriculture Department have popularized the methods of conserving compost and farmyard manure, but we consider that the Local Authority should take this matter into consideration and have by-laws framed so that the departmental directions are systematically observed. An intensive and demonstrative propaganda is needed to convince the cultivator what pitfalls he has to avoid.

The Committee note that wherever lift-irrigation has come in, there is a tendency in areas where stall-feeding has not established itself, for dispensing with bullocks and substituting in their place he-buffaloes which are purchased when they are needed for the plough and sold immediately the ploughing season is over. This results in the unavailability of sufficient farmyard manure for the tenants' holdings. The cumulative effect is that soils are getting less organic manure day by day, while with flow irrigation commercial crops are

systematically being raised. Complaints have been received from a district like Etawah and the Committee recommend that in such cases the Statutory Authority must intervene. Wherever there is a society for the marketing of commercial crops there should be by-laws laying down the necessity for building up on the soils on which the crops are raised certain amount of compost or farmyard manure. Emphasis should also be laid on stall-feeding and raising of fodder crops, and cultivators should be encouraged to maintain bullocks and a cow to complete their agronomic economy and avert the devastating consequences of raising exhaustive crops without applying adequate manure for replenishing the soil with its normal nutrients.

There are many jungle grants given out for the purpose of clearance of jungle and establishment of cultivation. There are punitive sanctions attached to these grants regulating the pace of clearance. It is necessary to re-examine these grants to see whether deforestation has not interfered with the general economy of the area in the sense of removal of all check in the flow of flood water. The trees with the root system constitute a powerful binding material which keeps the soil *in situ*. The forest area, scientifically thinned, will continue to constitute a valuable fuel and fodder preserve. The Chairman understood from the Settlement Officer, Kheri, that there were areas known as *Bachhela* in Kheri which were remnants of the old forests. The local authority that is being set up should be in a position to order that certain area of *Bachhela* proportionate to the area actually brought under cultivation should remain covered with trees and serve as fuel and fodder preserve and should not be allowed to be further cut down. The same would apply to *Bachhela* areas in the Gonda District.

The Committee fully realize that the financial pressure that looms large in any scheme of farming that the farmer works out restricts him to the selection of crops which yield him a prompt return unless he is a man of many acres. There is no planning of cultivation with a view to giving his fields a rotation of rest or a rotation in the shape of soil-enriching fodder crops. The Committee would strongly urge it for the consideration of substantial tenants and for middle class zamindars that a *penchant* for home farming or mixed farming be set up, that is, they should go in for raising of herd and devote a portion of their cultivated land for purposes of growing fodder crops needed for stall-feeding of the herds. Not only would they be in a position to net in a good income from the sale of young stock and milk products, but they would be indirectly enriching the soil by allowing it rest from growing cereals and other commercial crops, and giving the soil the benefit of a season under a leguminous crop. In the Middle Ages in Europe when there was co-operative farming certain rules were laid down which gave soil the opportunity for recuperation in any scheme of collective farming, such as is practised now in U.S.S.R. If we have mixed farming, we shall be compelled to put a certain area under

leguminous fodder crops like *berseem*, lucerne, etc. and we shall thereby be adding not only to the total fodder content of the village but also making the plot fertile that is at present probably lying barren.

The whole thing boils down to some system of at least a five-year planning with a certain margin of fluctuation and provision of substitute crops. But we must treat the land as a living entity and plan for its rhythmic periods of work and rest so that the micro-organisms of the soil may have optimum conditions to work in for the elaboration of food constituents for the plant that is on the surface.

Complaint has been made that good agricultural land is being thrown out of cultivation in Muttra and Agra Districts and in areas adjoining Gurgaon and Rajputana. The trouble in this tract is that the desert is insidiously extending on the cultivated area. Ordinary explanation forthcoming is that there has been poor rains for the last few years but the chief difficulty as already indicated lies in what Mr. Mehta of the Punjab Irrigation Department said that on account of the slope towards the Jumna and the absence of *bundhis* there was a rapid run-off of rain-water and consequently smaller addition of rain-water to the water-table. He described the investigation carried out in the Bisht Doab and advised 'Watbandhis.' The Committee fully endorse those views and strongly recommend afforestation of the area encouraging growth of grass with controlled grazing and putting up embankments at strategic points.

We feel that, as has already been described in the chapter dealing with reclamation of other waste areas, that in the interest of soil conservancy every effort should be made to restore the balance between the cultivated area and area under grass and trees. The ideal would be 20 per cent. under trees. In the United Provinces the average works out to 6 per cent. and here the afforestation is satisfactory only in 15 districts. We want this department to be in greater evidence in every district, the object being to ensure a well-balanced agricultural economy.

In this connexion the Committee would like to draw attention to the work of soil conservation that is being done in the U. S. A. Messrs. Jacks and Whyte in their book 'The Rape of the Earth' have quoted a passage from an American publication which clinches the issue :

'In no other field of our economic activity has the doctrine of *laissez faire* been given freer rein than in the use of our agricultural land. Farm lands have been used and abused and bought and sold as mere commodities, practically without restriction. Indeed, the extreme of *laissez faire* has been reached with respect to some of the Federal Government's own lands, on which unrestricted grazing has been permitted to the point of destroying valuable range resources.'

' This attitude contributed to rapid expansion and development, but at the same time produced a planless, crazy-quilt pattern of land use, destroyed or impaired a large proportion of the Nation's irreplaceable resources, and wrecked the hopes, aspirations, and the very lives of untold thousands of people.'

America has taken up in its Agricultural Adjustment Act the important question of national conservation against the position of vested interests which are mainly international and aim at maximization of wealth. The refusal of the U. S. A. to take payment in goods from their debtors and high tariffs imposed by, and the poverty of the debtors, caused enormous drop in agricultural exports. The A. A. A., by which name the Act is known, aims at restricting production to the probable domestic requirements by allotting maximum acreage for different crops. The A. A. A. was a shot in the design to prevent the conservation of soil capital into goods unwanted by a fast growing nationalist world. The Act has come to stay and to develop as an instrument for conserving soil capital. The Committee feel that a note of warning cannot be sounded a moment too soon by them when they emphasise the fact that our first consideration should be to preserve our national capital in the shape of our memorably fertile soils being wasted away by a system of uncontrolled and unplanned cropping, which rob the soil of fertility and in the long run make the position of the cultivator economically untenable.

The transition in the U. S. A. from the unrestricted private tenure to public protection of the land is evidenced by the passage of the Taylor Grazing Act (1934) which 'authorizes the withdrawal from entry of 80 million acres of vacant, unreserved, unappropriated public domain and its organization into grazing districts to be administered by the Department of the Interior. It also authorizes administration of grazing on land included in withdrawals amounting to about 30 million acres in so far as grazing is consistent with the purposes of the withdrawal . . . Broad powers are conferred on the Secretary to do any and all things necessary to accomplish the purposes of the law, namely, to regulate occupancy and use of grazing land ; to preserve the land and its resources from destruction or unnecessary injury ; to provide for the orderly use, improvement, and development of the range ; and to continue the study of erosion and flood control and to perform such work as may be necessary amply to protect and rehabilitate the range lands.'

The problem that goes to the very basis of any scheme intended to secure maximum outturn from land is the problem of the tenants' holding, its size and the law that governs its devolution. If we are to ensure economy in *mends* or border strips separating plot from plot, we have to ensure some kind of compacting and in the absence of compacting, some kind of co-operative farming. By this means

we may be in a position to remove the uncultivated strips between field and field and put the whole area under uniform crops. If block cultivation of the same crop is made the order of the day, we can get irrigation from tube-wells cheaper than is the case at present and we can ensure regular supply of adequate water from canals. The present system militates against anything that would reduce the cost of cultivation and the tenant is not in a position to give the necessary rest to his area because he misses the benefits of large-scale farming and he has to make up for this loss by intensive cultivation of his small scattered bits of land. This explains the growing incidence of *Dofasla* cropping as we proceed from west to east because from his smaller holding the tenant has to eke out his living and enough income to pay rents. For instance, if five tenants can combine together and pool their resources of an average of 4 acres each, we have 20 acres of land. We shall be in a position to have an effective area of 20 acres when we have removed all the *mends* that separate field from field. The crop rotation may be so arranged that one-fourth area might be put under leguminous fodder crop which would not only yield sufficient fodder for the cattle of those who have joined together in the pool but would enrich that soil.

It is in this way that in every four years the original field would have recouped itself by bearing leguminous crop instead of ordinary cereal or sugarcane. Even where laws of inheritance are allowed free play and fields are reduced to small strips, the Co-operative Department must step in and bring about co-operative farming, have the consolidation of holdings, and as far as possible the waste that at present occurs in the shape of strips of land separating field from field be avoided. Irrigation channels when they have to reach these small strips of land cause a lot of waste of good land. If there is a compact block and *kiyaris* are set up in this compact block, we can irrigate the whole area from one irrigation channel instead of having 20 as the minimum number for irrigating such an area. We save in *mend* and we save in irrigation channels if we go in for consolidation of holdings of better still co-operative farming.

As regards organization, we have already given the outline of the provincial organization to control and co-ordinate research work and to mobilise the resources of the State and the departmental staff of nation-building departments for the purpose of co-operating for the improvement of village conditions. We are interested as owners of the land in the preservation of its fertility. We are equally interested in seeing that the village cultivator, who exploits the land, operates with efficiency without impairing the permanent fertility of the land and therefore while providing for a provincial organization, mobilising men and money for achieving the object in view, we must concentrate on statutory authorities being set up with their base riveted in village organizations set up under the Village Panchayat

Act, under the Co-operative Societies Act or by the Statutory Authority set up under the contemplated Rural Development Act. We cannot help envisaging the future conservational activities of the village as lying completely within the orbit of the better-living society of the village organization. This society must have statutory powers to take up the work of improvement and to enforce by its by-laws compliance with the recipe prescribed by technical experts for improving the output in village agriculture and providing better grazing for the cattle and more varied diet for the villager.

These village organizations will work under Unions and the Unions will work under the District Committee. Our Rural Development Act should therefore aim at setting up a provisional organization with the village organization serving as the base. The permanent staff working under the Land Reclamation Board will be necessarily of the research type. The other staff will be working under the respective departments of Agriculture, Forest, Veterinary, Irrigation, Revenue, etc. Each departmental officer will in his own way contribute towards the consummation which we all desire, namely, improved life of the villagers and conservation of the fertility of the soil. The initiative will have to come from the village unit travelling up to the Union and thence to the District Council. The strength of the organization will be the strength of the village units statutorily empowered on which it is to be broad based if it is to function according to the ethos of the Indian peasant.

CHAPTER VI

INDUSTRIAL ASPECTS OF ALKALI DEPOSITS

THE Committee feel that mainly through the efforts of the Industries Department it should be possible to turn to useful account the vast quantities of raw chemicals which have appeared as efflorescence on the *reh*-encrusted usar lands. These deposits are predominantly in evidence in the districts of Aligarh, Agra, Mainpuri, Farrukhabad, Etah, Cawnpore and Unao.

The *reh* deposits contain considerable quantities of sodium salts, mostly carbonates, besides sulphate and chloride. The practice of extracting the soluble alkali salts from these soils has been in existence in this province for a very long time. The scraped *reh* is collected at a suitable place and lixiviated with water. The aqueous extract is filtered through a bed of straw and twigs in order to get rid of the insoluble earthy matter. The filtrate is then allowed to evaporate in open tanks exposed to the sun. The solid residue thus obtained is sold as *sajji*. This operation is mostly done in summer months in open fields when *loo* blows, helping the evaporation. *Sajji* as is well known

is used by *dhobis* and also to a small extent for soap making after mixing it with causticising solution. The composition of *sajji* as worked out by Dr. Watson and Mr. K. C. Mukherji of the Department of Industries, United Provinces, in 1922 is given below :

	Per cent.
Insoluble	5—10
Water	20—40
Sodium carbonate	30—60
Sodium sulphate	2—20
Sodium chloride	1—5
Organic matter, etc.	2—7

It will appear that sodium carbonate is the main constituent of the *reh*.

In a large area of *usar* land examined the proportion of sodium carbonate to sodium was roughly found to be 2 : 1 with a smaller proportion of sodium chloride. If the sodium carbonate is not purified to the European standard, the glass manufacturers would not take up its use as they can easily get a standard product which would give them uniform satisfaction and result. The following three methods were tried for purifying and utilizing the sodium carbonate and sodium sulphate from these *reh* salts or *sajji* :

(1) If the *sajji* is crystallised from water some amount of sodium carbonate is obtained, which conforms to the European standard. The residue, which generally contains the sodium carbonate and sulphate in equal proportions, may then be subjected to the ordinary Leblanc process which would convert the sodium sulphate into sodium carbonate.

(2) If the *sajji* solution is causticised with lime nearly the whole of the sodium carbonate is converted into caustic soda. If the filtered solution is then evaporated sodium sulphate crystallises out almost completely and caustic soda of good purity may be obtained by concentrating the liquor.

(3) The sodium sulphate obtained from the above process may be easily converted into sodium sulphide of European standard by heating with charcoal, extracting with water and crystallisation. There is a demand for sodium sulphide in the leather and dyeing trades.

It is estimated that 7 to 8 lakhs of maunds of *sajji* are marketed every year in this province. The following figures give the quantities of alkali imported into India in 1936-37 :

	Weight in cwt.	Value in rupees
Soda ash or soda crystals	1,250,670	50,89,473
Sodium bicarbonate	121,257	5,93,089
Caustic soda	424,013	36,57,443

This opens up a field for inquiry as to how to replace imports by local manufacture from the raw material.

The area between Phaphund and Etawah was examined in details by Dr. Watson. By taking one inch scraping in many places and then analysing the earth as to its content of sodium salt, it was found that this area could give 37,450 tons of sodium carbonate, but if two-inch scrapings were removed, it could yield 58,510 tons of sodium carbonate. It is very important to know whether this amount would be available annually or it would decrease. Some experiments were done by the Agriculture Department of the United Provinces in which scrapings were removed from one plot of *usar* land for 19 years continuously and the output showed only a small fall.

This opens out a vast field for research. At present the only use to which the salts are put is for the *dhobis* for washing or the local glass blower, the *manihar*, who makes bangles and crude bottles for ottos and hair oils. The vista that once opened out before the Industries Departments of the United Provinces with this raw material which could be purified for purposes of supplying the growing demands for pure soda carbonate in areas where there are factories of glass and paper and have been closed on account of the large-scale works that have been initiated by the Gaikawar-Tata works at Okha and the proposal of the Indian Chemicals in the Punjab to start similar concerns in connexion with Khewra mines as also the contemplated works in Sind. We are therefore reduced to the investigational utilization of this raw material for industries on cottage-scale basis. *Sajji* is *dhobi's* soap. Sulphate of soda is used for dyeing. The *manihar* will need it for his bottles, beads and bangles. Sudden interest has been concentrated on this raw material in view of the ordinances recently promulgated prohibiting the export of carbonate and bicarbonate of soda. We are therefore to see that along with potassium nitrate, the *shora* of the villager, the collection of *sajji* and *khari* is brought within the ambit of organized collection by village societies. It may be possible to improve village furnaces for making the crude glass needed by villagers.

While the report was being considered, war had broken out between England and Germany, and it was reliably understood that the machinery ordered for Okha from Germany would not now be delivered. The transport facilities from port to port on account of shortage of shipping difficulties open out scope for the local industry to go ahead. The Director of Industries has been addressed on the subject.

In the suggestion made above, it is clear that tracts of *reh*-encrusted *usar* will have to be left as such to enable them to yield sodium carbonate year after year and this removal will not improve by any means the land for agricultural purposes. The Committee therefore

recommend that large-scale cultivation of 'Saltworts' be resorted to on all our *usar* lands showing *reh*-encrustation.

The name 'Saltwort' is given to two species of plants both belonging to the family *Cheenopodiaceae*, viz., (i) *Salicornia herbacea* (ii) *Salsola kali*.

Salicornia herbacea which is saltwort proper grows on sea coasts. *Salsola kali* also known as glass-wort grows both on sea coast and salt steppes.

Salsola kali is not, however, recorded from India, but there are three other species which grow in the Punjab. These are (i) *Salsola foetida*, (ii) *Salsola verrucosa* and (iii) *Salsola vermiculata*. Of these according to Dr. S. N. Das Gupta of the Lucknow University, *Salsola foetida* is very common in the plains of the Punjab. It is also found in the districts of Delhi and Agra.

Saltworts remove a large proportion of salts from *usar* lands, so much so that some of them contain salt up to 15 to 20 per cent. of their dry weight. These salts are recovered by burning the dry percentage of material and the famous *khar sajji* or *khar* in the Punjab has a high sodium carbonate in it. By growing these saltworts for a few years in *usar* lands, the salt content of the affected land decreases sufficiently to enable a normal crop to be grown.

Dr. Puri, Soil Chemist, Punjab Irrigation Research Institute, stated in his evidence before the Committee that saltworts, known as 'khar booti' in the Punjab, are grown in the Muzaffargarh and Multan Districts for reclaiming alkali soils. *Khar booti* grows in soils having a pH value as high as 9. The dried plant yields 15 per cent. of sodium carbonate having 98 per cent. purity, weight to weight. In the Punjab according to Dr. Puri, it has been found possible to reclaim alkali soil without any water in three years' time with 'saltworts'. *Suaeda fruticosa* can also be grown in alkali soils; but it contains only 1 to 2 per cent. of sodium carbonate.

The Agricultural Chemist, Punjab, will shortly take up cultivation of saltworts on the Jhung Farm to examine the utility of saltworts for reclaiming alkali lands and also as a source of *sajji*.

Unfortunately, no analytical data are available to show the exact composition of saltworts found either in the Punjab or Sind. Salt bushes of various types are common in Sind as well as in Bikaner and other Rajputana States. In those places they grow spontaneously and are eaten by camels. Analytical data of the three types

of salt bushes occurring in Sind have now been received from the Agricultural Chemist, Sakrand, Sind and are given below :

Name of bush	Ash Percentage	Chloride Percentage	Sodium Percentage
Lani (<i>Salsala suaeda</i>)	24.5	0.6	5.0
Creeping salt bushes	26.0	6.3	5.7
Old man's salt bush	25.0	9.0	6.5

The Chairman recently secured from the Inspector General of Customs of the Bikaner State a sample of salt bush commonly grown in the desert together with samples of soil on which it grows. These samples have been analysed by Dr. Mukerji and the results are given below :

(i) *Analysis of soil growing salt bush in Bikaner*

	Percentage
Na ₂ CO ₃	0.053
NaHCO ₃	0.090
NaCl	0.034
Na ₂ SO ₄	0.56

(ii) *Analysis of salt bush from Bikaner State*

Na ₂ CO ₃	0.080
NaCl13
Na ₂ SO ₄	1.172

The soil it grows on is predominantly saline (sodium sulphate) and therefore the salt bush when burnt is found to be predominantly rich in sodium sulphate.

The Chief Conservator of Forests, United Provinces, has agreed to have experiments made on the *usar* areas along the canal banks on the growth of saltworts. This would enable us to see whether apart from the value of the ash obtained by burning the plant material, the growing of the plant results in the removal of injurious alkali salts from the soil.

The Committee recommend that arrangements may be made both with the Forest Department and Agriculture Department for laying out small-scale experiments scattered all over the province to examine the potential value of saltworts both as a source of *sajji* and also as an agent for reclaiming alkali soils.

Saltworts, as known in the Punjab and Sind, are purifiers of areas rich in sodium sulphate. The same is the case in the Rajputana deserts. Our problem, on the other hand, is to purify the soils predominantly rich in sodium carbonate and it is, therefore, necessary that the Botanical Sections of our universities or the Agriculture

Department should evolve some strain of saltworts which might flourish in soil rich in sodium carbonate, with the result that the soil will be sweetened and the injurious salt removed by the plant.

Observations at Coimbatore show that *Ragi* (*Eleusine coracana*) is very tolerant of alkali. Fodder crops like lucerne have also been tried with less success. Of fuel trees, *babul* (*Acacia indica*) seems to grow well in the alkaline soils here. The whole idea is to enable this vegetation to open out the soil liable to water percolation through the salt-encrusted strata and wash out the injurious salts.

In Sudan the experience has been that salt bush *Atriplex semi-baceatum* and *A. nemmularium* grow on saline soils and remove salts from the soil when they are pulled out and burnt.

CHAPTER VII

RESEARCH

The statistics at present available in the province for the different classes of soil has been collected chiefly through the *patwaris* who have no special training to carry out a scientifically correct classification of soils. It is obvious, therefore, that the figures returned by them for *usar* or 'reh-encrusted *usar*' are far from being correct. The Settlement Officers of the province are definitely of the same opinion. In order, therefore, to understand the magnitude of the work involved in undertaking land reclamation in the province, it is a matter of first and foremost importance that we should have correct knowledge of the different types of soils and the area occupied by each. The necessity for classifying the different soils of the province on scientific lines is thus clearly indicated.

The Committee have already recommended the setting up of the Waste Land Reclamation Board. It is suggested that the same Board will control experimental work in the following directions :

(i) Devising a rough and ready method of soil classification of the *usar* areas (*usar* used in the general sense) for the guidance of the Land Records staff so that the Board may soon be in a position to know how much of this *usar* is infertile on account of salinity; alkalinity that shows on the surface; alkalinity that does not show on the surface; alkalinity that does not show itself on the surface but makes the soil texture impervious; sandy texture; waterlogging and any other ascertainable factor.

(ii) Detailed examination of typical soil profiles with special reference to their chemical and physical composition in order to test whether the classification that is empirically made is correct from the point of view of the internal structure of the soil and its chemical composition.

The investigational work in connexion with soil survey in the United States of America includes the following four objectives :

- (1) to determine the quantity of concentration of soluble salts in representative areas and their characteristic distribution in the successive layers of the root zone ;
- (2) to ascertain their composition by analysis ;
- (3) to identify, if possible, their source ; and
- (4) to explore the possibilities of their removal by leaching and drainage.

It seems necessary that a rapid soil survey, more or less on the lines indicated above with modification to suit our problem, be undertaken for the whole of the province. For this suitably trained field-workers will have to go out to the districts and in association with the *patwaris* classify the land under various labels according to certain outstanding factors which the work in the laboratory has revealed as the distinguishing marks for different types of infertile soils.

It is necessary to analyse waste areas other than strictly alkali areas so as to find out the causal factors of soil sterility ; e. g.

- (a) which of them at present lying waste or bearing merely scattered trees or intermittent grass cover are reclaimable so as to grow more (i) grasses of improved quality and in larger quantity, (ii) trees for fuel purposes and (iii) food and fodder crops ;
- (b) which of them will respond economically to irrigation ;
- (c) what type of soils are apt to get waterlogged and deteriorate to *usar* conditions ;
- (d) which of the alkali soils are worth reclamation and by what methods, and at what level of alkalinity our soils can be considered to have been sufficiently reclaimed for crop production. Besides the Punjab the Bombay Presidency has also worked out details which would be useful in determining the level of soil alkalinity for tolerance to food and fodder crops.

Generally speaking, while for irrigated crops sodium saturation up to 10—15 per cent. (i.e. per cent. exchange—sodium on the total base—saturation capacity) is not perceptibly bad, for dry crops 5—7 per cent. may be considered high. Crops like *berseem*, *dhaincha* (*Sesbania aculata*), and sugarcane can stand sodium saturation even up to 30 per cent. (although the yields are lower with higher sodium saturation). Only when sodium saturation is over 30 per cent. reclamation by artificial methods is essential. Otherwise, crop growing with irrigation and manuring is sufficient to gradually reclaim these soils.

It is also extremely necessary that we must have much more detailed knowledge than we possess at present about the vertical and

lateral movement of water in the soil during the different seasons of the year, specially in the canal-irrigated areas or areas where there is likelihood of extension of canals. Any change in the amount of water indiscriminately introduced in an area without adequate knowledge of the vertical and lateral movements of the sub-soil water is likely to upset the agronomic economy of the particular area.

Mr. Thorp in his suggestive study of 'Geography of the Soils of China' writes :

'In establishing new irrigation projects in a semi-arid region the matter to be taken into consideration is that of drainage, no matter how well the soils drained under the existing natural conditions. What we have to see is what steps are taken to drain effectively the area after it is subjected to more intensive irrigation.'

We have bitter experience in the past of canal irrigation having been introduced in the Aligarh District without providing for necessary drainage with the result that there was a rise of the sub-soil water-table and fields were thrown out of cultivation on account of the salts in the soil profile coming up in solution by capillary action to the surface of the soil and depositing themselves there as a result of evaporation. Canal irrigation is to be shortly introduced in the Partabgarh District. It is an intensely cultivated tract. We have no knowledge about the tolerance of the soil to further irrigation of the flow type. We are without data as to the necessity for the provision of drainage channels so as to prevent the disastrous consequences of any adverse changes in the lateral and vertical flow of sub-soil water.

The Committee feel it imperative to carry out intensive laboratory and field-scale research to ascertain the optimum watering necessary for different crops and different soils.

In some places the soil conditions might be such that light irrigation would bring about impregnation of the soil with salts which may show a tendency to come right up to the surface instead of being driven down to the water-table to be washed away by sub-soil drainage. Dr. MacKenzie Taylor, Director, Punjab Irrigation Research Institute, Lahore, laid considerable emphasis on this feature of his work which the Chairman and the Secretary had occasion to see on the reclamation farm at Renala.

So far as conditions in the United Provinces go, research work on these lines is urgently needed so as to be able to ascertain with certainty the possible reaction of different soils types to intensive gravity-flow irrigation.

It is also necessary to take up the question of the inter-dependence between over-irrigation and formation of *reh*. Villagers have complained that owing to the faulty alignment of the canal and to the insufficiency of the drainage, waterlogging has taken place in their

fields, with consequent rise of salts by capillary action on the surface. The Technical departments, however, attribute waterlogging to over-irrigation. We have insufficient data to judge what brings about saline conditions and whether irrigation in excess of the requirements would cause any deterioration in the soil texture.

The Committee feel that where there is no question of lateral seepage or interference with the drainage of sub-soil water, precise information is necessary on the fundamental point regarding the relationship between the quantity of canal irrigation and incidence of *reh* or alkalinity under varying soil and crop conditions.

In addition to the need for carrying out investigation on the lines indicated above, it appears that a good deal of success can be attained if attention is directed to the botanical aspect of land reclamation. Till now there is no information in the United Provinces as to whether the natural vegetation on inferior soils could form an index to the texture of the soil, considering the flora to the ultimate result of climatic and edaphic factors. The Committee feel that it would serve a very useful purpose if ground vegetation could form a basis of visual soil survey.

In addition to the ecological survey suggested above attention should also be directed to an intensive research as to the strain or strains best suited for certain types of abnormal soils. Considerable success can be attained in carrying out large scale reclamation if it were possible to grow on moderately reclaimed *usar* soils varieties of crops capable of tolerating soil alkalinity to a very marked extent. In other words, if we cannot hope to bring a soil to the condition of absolute normality with reasonable expenditure and labour it is certainly desirable to ascertain what stage of reclamation would be necessary so as to enable us to grow on that partially reclaimed soil certain strains which have been specially developed from the point of view of tolerance to alkaline and saline conditions. There should thus be a concentrated effort to collect information on the relative tolerance to soil alkalinity of the different strains of the more important crops, e.g. rice, millets, pulses, oil-seeds, wheat and sugarcane. As far as rice is concerned we know that T-17 or T-23 can stand soil alkalinity to a greater extent than say, T-21. Certain saline-resistant varieties of rice have also been evolved for cultivation on the sea coasts of Orissa, Madras and Bombay.

With a view to improve grazing in *usar* tracts and augment the supply of fodder in the province, it appears extremely desirable to the Committee that botanical investigation be undertaken in the province with a view to study the natural development of grasses in the *usar* areas. The necessity of obtaining a continual agrostological record has also been emphasized by the Fodder and Grazing Committee, United Provinces, and the Committee understand that steps are being taken to send a suitable botanist abroad for training.

We have already suggested the setting up of a Waste Land Reclamation Board with a Soil Chemist as its Technical Secretary. In selecting this officer the Committee strongly recommend that preference should be given to one who has worked sufficiently long in the Agriculture Department so that he may have a thorough acquaintance of the agricultural conditions of the province besides possessing a sound theoretical knowledge of the subjects. In order to secure the services of a really competent man it would be necessary to make this post of Class I Provincial status. Under this officer there should at least be two competent Research Assistants in the Class II Provincial grade—one for dealing with the chemical aspect and the other for the physical aspect of the problem. In addition to these officers it will also be necessary to provide for a suitable number of assistants in the subordinate grades. If necessary, the Committee will have no hesitation in recommending that Government may send a suitable officer abroad for a period of eighteen months to study at first hand soil reclamation problems which are being tackled in Italy, Hungary, Holland, America, South Africa and Egypt.

It seems desirable that research on the following lines should be started as early as possible :

- (1) Soil (pedological and manurial problems).
- (2) Ecology, inclusive of agrostology.
- (3) Physiological work.
- (4) Plant breeding.
- (5) Agronomy.

The Committee suggest that in view of the headquarters of the Agricultural Chemist being at Cawnpore and the facilities that already exist there for work on soils, research work on soil problems be conducted at Cawnpore.

The Committee further recommend that a portion of the work on soil problems be also conducted in Dr. Dhar's research laboratory at Allahabad and the research students of the Allahabad University also should work in the same laboratory.

The Committee recommend that plant problems (physiology and ecology, inclusive of agrostology) should be concentrated in the Institute of Agricultural Research of the Benares Hindu University in view of the facilities and guidance already available there for physiology and ecology, inclusive of such problems and such agronomical work bearing on crop production.

The Committee further suggest that a portion of the systematic work on grasses be allotted to the Lucknow University.

The work on plant breeding may also be taken up by any other university or institution according to facilities available.

The Chairman ascertained the views of the different univ the United Provinces in the matter of the extent to w specialist departments could co-operate in the work of re our soil problems. The Committee are strongly of opinio co-operation, as far as it is available, of university researc ments should be sought by the Waste Land Reclamati and the *modus operandi* to be adopted would be to allot problems according to the facilities available by way of laboratory accomodation in different universities.

The reply from the Aligarh University has not been rece we would like to recommend that should there be facilities fo on soil problems, the question of the movement of the water the canal-commanded *usar* tracts of Aligarh District would appropriate subject.

CHAPTER VIII

ACKNOWLEDGMENTS

Dr. B. N. Singh proposed that the Committee should record its deep sense of appreciation of the invaluable services by the Chairman and the Secretary in preparation of the r was seconded by Dr. N. R. Dhar and supported by Raja J Bakhsh Singh, and the proposal was unanimously passed that may form part of the report.

Members who signed the report

- (Sd.) V. N. MEHTA. 25-10-'39.
(Sd.) VISHNU SAHAY. 25-10-'39.
(Sd.) E. A. SMYTHIES. 25-10-'39.
(Sd.) B. N. SINGH. 25-10-'39.
(Sd.) MANAK SINGH. 25-10-'39.
(Sd.) RADHA MOHAN SINGH. 25-
(Sd.) JAGANNATH BAKHSH SING
25-
(Sd.) MOHSIN ALLI. 25-10-'39.
(Sd.) N. R. DHAR. 25-10-'39.
(Sd.) B. K. MUKERJI. 25-10-'39.
(Sd.) MASON VAUGH. 26-10-'39.
(Sd.) HAR PRASAD SINGH. 27-10-