YEMEN ARAB REPUBLIC

The Montane Plains and Wadi Rima' Project
– A Land and Water Resource Survey –

Observations on institutional and related aspects
of irrigation improvement in Wadi Rima' and
on prospects for afforestation and livestock improvement

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Foreword

Mr B J Hartley MBE OBE CMG was engaged by the Ministry of Overseas Development on a short-term contract 'to advise on appropriate points of the MFWR Project as agreed with the Project Manager, including particular reference to institutional aspects of irrigation development in the Wadi Rima'.

Brian Hartley was engaged for this assignment because of his wide experience in arid lands development. After service as Agricultural Officer in Tanzania (then Tanganyika) he transferred to the Aden Protectorate, where he launched the Abyan Irrigation Scheme and served as Director of Agriculture, before leaving in 1954 to work with FAO first in Iraq and latterly in Somalia. Since 1973 he has been assisting the Ethiopian Government in formulating livestock development projects under World Bank auspices.

This report was drafted towards the end of his visit to the Project (8-21 December 1975) and in its present form incorporates additional material provided after his return to Addis Ababa.

D J Pratt
MFWR Project Manager
1. Irrigation Improvement in Wadi Rima

1.1 Background

Reference has been made to several documents describing conditions in Wadi Rima, particularly those dealing with the present system of water use and the dispute over the 'new' canal Mashrabi al-Hukumah and the lands which it irrigates at al-Jarubah.

The surface water supplies in the wadi take three forms:

(a) Ghail, i.e. the permanent flow (clear water) found in the upper reaches of the wadi.

(b) Sall, in the form of base flow from freshets and minor floods which boost the ghail, and which may be almost continuous from April to October, and

(c) Sall (kabin), in the form of high flood spates which may occur two to four times between April and October.

1.1.3 Diversion of the permanent flow, mainly in the uppermost reaches of the wadi, is by stone and brushwood (makfa) deflectors. In many instances the flow is conveyed through small canals over comparatively short distances to low level lands adjacent to the wadi. Some, however, is wastefully conveyed in larger multi-purpose canals, such as the Mashrabi al-Hukumah of the north bank.

1.1.4 Diversion of the sall base flow is again by stone and brushwood deflectors, in places strengthened by bulldozed material of sand and gravel from the wadi bed. The flow may pass through the permanent flow systems but for the most part is conveyed in the large canal systems, which can take both base flow and heavier spate flow for as long as the headworks stand.
1.1.5 Diversion of the sail high flood is by the deflector systems described above and by sand barrages ('ugma) built across the wadi. The latter effect complete diversion into large canal systems and may also provide 'slack water' inundation as the water backs up behind the 'ugma' sand barrage.

1.1.5 Regulation is effected by opening the maktef defectors. The system also has an in-built safety device in that high floods sweep away the defectors before too much of the flood enters the canal system. In the case of the 'ugma' barrages, no regulation is attempted, the whole flood flow being turned.

1.1.7 Transmission of flows is mostly through the main canal system and from this straight into the bunded field system. Earth 'plugs' which dam the main canal are used to turn the water. When a section of bunded land has been inundated the plug is breached and the water flows down to the next turn-out point. Flood flow, and often base flow also, is passed from field to field by breaching the bunds, without the use of a secondary canal system.

1.1.3 In short, while it may be said that diversion is effective - being achieved economically with local materials, albeit without a proper control system - transmission, which requires that flows be passed through breached bunds and from field to field, is wasteful of water, time consuming, and costly in repairs and general maintenance.

1.1.9 And it must be concluded that, whatever the socio-economic and political constraints, improved water management can only be achieved by restructuring the transmission system, to permit water to be conveyed through the main canal to secondary and tertiary canals for delivery to each field. Control works at the intake and turn-out gates and drop-structures along the canal system are all needed, and will require investments in design and materials. When complete, operation of the system will need to be entrusted to an efficient organisation, vested with legal authority and backed with the necessary finance and skills to enable it to function properly.

1.2 Improvement through legislative and institutional changes

1.2.1 Modern trends in water legislation aim at institutionalising, in one form or another, the concept of community of interests, which concept, in fact, constitutes the traditional basis of Moslem Customary Law/1.

/1 Water laws in Moslem Countries' FAO Irrigation and Drainage Paper 20/1 (1973)
1.2.2 Until now water administration in the YAR has remained customary. The principles of the Shari'ah regulate the use of water for domestic and agricultural uses, including both surface and underground water. Traditionally water cannot be sold unless contained in tanks, receptacles or other prescribed containers. Irrigation water is not sold, though the relinquishment by one irrigator of his right to water in favour of another irrigator may be subject to monetary compensation.\(^1\)

1.2.3 The YAR has no National Water Policy or centralised water administration. The institutions required for the conservation, development and use of water (a natural resource which constitutes an essential component of the National Wealth) need to be established.

1.2.4 Institutions for water development and management usually require representation at the national level, at the intermediate or district or basin level, and finally at the user level, through water user associations and water boards.

1.2.5 Government control and supervision of water must be established on a legal basis, to enable the scarce resource of water and, where appropriate, the land adjacent to it, to be brought under state control; and to enable planned intervention to be made to ensure an efficient, equitable, and socially acceptable use of the resource.

1.2.6 Specifically, there is need for a Water Development Proclamation to be enacted to enable the YAR to do the things which should be done, and prevent things which should not be done, while providing a known and rational framework within which rights can be ascertained and secured.

1.2.7 Within this framework, an efficient Executive Agency needs to be established at Ministerial or inter-Ministerial level, with the necessary skills and financial resources, and with clearly defined responsibilities and powers, so that the work to be done for the development of the water resource can be identified and quickly and efficiently implemented.

1.2.8 The Water Development Proclamation should provide also for the establishment and appointment (and dismissal) for each Water Development Area (such as Wadi Rima') of a Water Development Authority responsible for that area. These Water Development Authorities should have delegated power within this Water Development Areas to develop water supplies, control the indiscriminate development of water and license and regulate the management of water.

\(^1\) Op.cit.
1.2.9 The Proclamation should also provide for the establishment of Water Users Associations or Water Boards to be registered with the Water Development Authorities. These associations or boards should be legally constituted and responsible bodies fully representative of the water users interests.

1.2.10 The limits of each Water Development Area and of the user areas will need careful consideration. The economy of having a few large areas needs to be weighed against the likely effectiveness of such large units. For example, it is not considered practicable for the Tihama Development Authority (TDA) to act as a Water Development Authority. Rather, to ensure a closely bound community of interests, it is proposed that each main wadi system and the area it serves in the Tihama should constitute a separate Water Development Area served by its own Water Development Authority. Within the Wadi Rima Water Development Area, for example, there should be a Wadi Rima Water Development Authority, comprising representatives of the Administrative and technical branches of government and representatives from Water Users Associations established for each canal and `qanu` system.

1.3 Relation of legislative and institutional needs to current development proposals

1.3.1 It is advised that no plans or designs for improvement on the Wadi Rima system should be made until the required legislation is enacted and the appropriate institutions are established, and an agreed socially acceptable means of water apportionment has been established. There is no merit in injecting into the indigenous system expensive capital works the benefit of which cannot be realised without further changes for which there is no legislative or institutional basis.

1.3.2 Acceptance of a new system will require acceptance of measures for restructuring the system (new headworks and inlet control, realignment of canals and the installation of secondaries and tertiaries, and the placing of turn-out gates and drop structures along the system) and for the application of a control system.

1.3.3 As regards groundwater development, the restrictions and controls to be exercised must depend on more detailed knowledge of current extraction, drawdown and replenishment. But as soon as legislative authority is available extraction in excess of 5 m³/day should be made subject to an extraction permit (as applies, for example, in Jordan).

1.3.4 Acceptance of controls and innovations is most likely to follow a solemn assurance that previously acquired rights will be accepted on the principle that `no land should be deprived of a share of the water sufficiently large to
maintain at least the production level obtaining under its historic water right\(^1\). But such a consideration is largely academic in Wadi Rima in view of the fact that the standard practice of Al 'A'mAL bils 'A'IN (or Al 'A'mAL fall 'A'IN), giving priority of use to upstream land, has been usurped by adverse possession of facilities and water and the evolution of a system of water selling to downstream users\(^2\).

1.3.5 Establishment of the ab antiquo water rights may be achieved through research of written records (tal'wid al-ard and land documents) as well as from sworn evidence and careful examination of land structures which indicate some use within a reasonable measure of time past.

1.3.6 Final acceptance may hopefully be achieved through conciliation (gulh), including relinquishment of the adverse possession of the Mershab al-Rukumah in favour of the downstream riparians and the community interest (including the share-croppers of al-Jaruba). But at some stage the national and community interest may have to prevail over private rights, and at this point the legislative and institutional processes can be applied.

1.4 Financial considerations

1.4.1.1 It is assumed that any development project for Wadi Rima will take advantage of the Agricultural Credit Fund (ACF) organisation established for TDA operations, to provide a vehicle for the supply of necessary credit funds.

1.4.2 Improvements of a capital nature on the wadi system may (in local terms) be costly but the life of such capital works should be long-term and not subject to high maintenance costs.

1.4.3 If an attempt is made to allocate the cost of capital works to the immediate beneficiaries, then the chance of obtaining their agreement to a plan for restructuring the irrigation system would be jeopardised. For this reason it is suggested that consideration be given to a plan which would use funds from a donor agency (or very long-term loan facilities) for

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\(^1\) As specified for Wadi Zahid: 'Proposed plan for water allocation' TDA/Tipton & Kalmbach (1974) P.15

\(^2\) According to Moslem law, flowing water is not subject to ownership, first because it is a gift from Allah and secondly because it does not satisfy the criterion of objective quantitative limits legally required for the constitution of private ownership rights; 'Water laws in Moslem countries' op.cit., YAR section.
the capital works thereafter, seeking recovery through indirect means such as increased tithes (ushur-zakat), increased internal trade and the saving of foreign exchange.

1.5 Development of groundwater

1.5.1 The development of this resource offers great opportunities and runs parallel with the utilisation of surface supplies. By diverting and holding flood waters on the land, surface flow otherwise destined for the sea is able to contribute to the recharge of aquifers, from which underground supplies can then be recovered.

1.5.2 Considerable well development has already taken place. However there are some negative aspects:

(a) There are no legislative or institutional means of controlling this development. Control of the right to install a lift irrigation system and control of extraction rate should be vested in the proposed Water Development Authority.

(b) The equipment used on pumping installations is of various makes, some of which is obviously unsuitable and costly.

(c) There appears to be a lack of servicing facilities.

(d) The standard of farming is far too low for the high cost water used.

1.5.3 Consideration should be given to measures to standardise equipment, especially where credit is involved. The TDA should consider setting up a Pump Maintenance Unit (with a mobile repair service and low cost bulk purchased spares) and should introduce a supervised credit scheme for lift irrigation operators. The latter would require borrowers to use correct inputs of fertiliser and crop protection measures and make use of high yielding proven crop varieties\(^1\). (The possibility of improvement in output on the permanent flow irrigated land is equally attractive, and also needs urgent attention).

1.6 Crop production

1.6.1 This subject has been dealt with by others and the following notes are given only to stress some aspects worthy of special attention.

1/ For example, instead of growing bulrush millet, yielding 2 tons grain/ha, grow one of the exotic maize genotypes yielding 12 tons/ha; or improved sorghum giving over 4.5 t/ha grain and 21 t/ha stover, against local types yielding barley 1 and 9 t/ha (TDA Agric. Res. Div. Tech. Bull. 1’ 1975).
1.6.2 Cotton. It is estimated that 5000 ha of cotton are grown at an average yield of 1 t/ha. The buying price for seed cotton is said to be YR 15 per farasila of 11.5 kg, giving a gross return of YR 1904/ha. The processing of this valuable material is done at Zabid, where the unclassified seed cotton is ginned in an ill-equipped old town building.

1.6.3 There appears to be no legislation of the sort needed to control the cotton industry. Such measures are needed in order to prescribe the time during which it is permitted to plant cotton, in order to achieve a compressed planting season and thus reduce pest damage, and the time when all cotton stalks should be uprooted and burned, in order to maintain a closed season during which no growing cotton is on the land to harbour pests and diseases.

1.6.4 The effect of time of planting on cotton yield has already been demonstrated at Wadi Zabid experimental farm, where August planting yielded about 1900 kg/ha seed cotton, September planting barely 1000 kg/ha and end-October planting as little as 350 kg/ha.¹

1.6.5 The Ministry of Agriculture and TDI are presumably the authorities with the power to make rules for the regulation of the cotton industry. It is suggested that sample legislation from progressive irrigated cotton growing countries be studied and rules prescribed and enforced.

1.6.6 Date Palms. Goldsworthy has commented on the semi-derelict plantations around Mijaylis, reporting that it was 'difficult to obtain information on the root cause of the neglect of this plantation'². However, on the occasion of my visit, together with the Project Manager, we were informed that the main cause is indebtedness; the plantations being mortgaged (rahn) with the result that no money is available for maintenance and replanting.

1.6.7 Whatever the cause, it is obvious that this valuable asset requires attention. Firstly, ownership patterns, servitudes, indebtedness and share-cropping systems need to be investigated. This should be followed by debt settlement and inputs of new capital with supervised credit to clean up and replant the area.

1.6.8 Dates are imported to the Y.R, and as there are large areas near the coast suitable for date palm production, it would seem appropriate to seek the advice of a date production specialist on the reorganisation and development of the date industry of the Tihama. The use of ICF finance through TDI would probably be needed for a long-term project to

restore and expand production. At present prices a date plantation can be highly profitable but about ten years may elapse before satisfactory production starts (although first fruiting may be at five years).

1.6.9 The use of World Food Programme ("WF") food aid could be a useful means of promoting establishment; say through a form of co-operative or community effort whereby poor landless families could be allocated land on which to plant date palms, and then be given follow-up supervised credit to grow the palms to a productive state.

2. AGRICULTURAL DEVELOPMENT ON THE MONTANE PLAINS

2.1 General observations

2.1.1 While opportunities for capital investment leading to increased production are outstanding on the Tihama, the opposite applies to the Montane Plains, where moisture availability through rainfall or underground supplies is the limiting factor, and is in short supply.

2.1.2 For this reason efforts must be made to increase water supplies and to make the best use of precipitation. In addition efforts must be made to improve production by the use of new plants, crop varieties and production methods, and by increasing animal production through improved breeds and management.

2.1.3 Once money is invested in tube wells requiring imported fuel for the lifting of water, so the full complement of other inputs of improved seeds, crop protection measures and fertiliser will be needed to maximise returns. A pilot project should be mounted to evaluate selected crop and livestock production systems using lift irrigation.

2.1.4 At some stage a careful cost-benefit analysis should be made to determine the comparative value to be attached to the use of foreign exchange to buy in fertiliser to boost local production of food crops, rather than spend the same amount of money on imported foods.

2.2 Water

2.2.1 Underground waters may be limited as to availability; they are most certainly limited as to sustained yield.

2.2.2 Better retention of surface run-off could be achieved through small dam structures in some situations where conditions of land ownership and run-off rights permit this. A more satisfactory method may be to develop water harvesting schemes whereby the plot holder or a small closely knit group construct a tank to hold run-off water
which can be used to boost production on small selected areas or grow special crops such as vegetables and fruit.

2.2.3 It is suggested that the MFR Project investigate possible sites and with the agreement of landowners construct trial water harvesting systems using plastic or butyl linings and also cement and plaster linings on the model of the Somali 'bercek' sunken cistern.

2.3 Crop production

2.3.1 There was not the opportunity during this visit to examine opportunities for new crops or varieties in any detail. In any event, the general situation has already been reviewed by Goldsworthy (op. cit.).

2.3.2 Relatively the greater opportunity seems to lie with range-land improvement (afforestation and fodder shrubs) and livestock development. Bee-keeping also has potential. These aspects are considered separately in the sections following. They have application to the Tihamah as well as to the highlands, as will be discussed.

2.3.3 There are several fodder crops other than fodder shrubs which deserve attention.

(i) Oilseed rape should do well in the higher rainfall areas and where run-in to the terrace is good. Rape has proved to be excellent forage and in the Chilalo Agricultural Development Unit (CADU) in Ethiopia it is anticipated that good use will be made of it for silage in highland areas.

(ii) Fodder beet, when irrigated and well fertilised, should yield 50 t/ha of roots. These can then be stored for dry season use, and should be a useful source of succulent forage to be fed with dry sorghum stalks. As labour becomes more expensive, the present custom of hand feeding sorghum stover in lengths which have been twined with green alfalfa will no doubt become unprofitable: simple hand operated chaffing machines and root pulpers might then be introduced for easy preparation of a mixed chaff and root feed.

(iii) Hairy vetch has proved to be a useful forage for highland Ethiopia. Some strains produce seed which can lie dormant in the stubble and grow away with the new rains.

(iv) Forage oats may be worth a trial, with emphasis on the quickest growing and most drought tolerant strains.
AFFORESTATION AND ESTABLISHMENT OF BROWSE TREES AND SHRUBS

3.1.1 Montane Plains

3.1.1 The highlands have been despoiled for centuries, and have in the process been robbed of their vegetative cover. Trees and shrubs have long ago been removed for building material and firewood, and the smaller woody plants are now grubbed out for fuel. Examination of the remaining plants will show that most of them are unpalatable species unused by grazing animals.

3.1.2 The above note refers particularly to the rangelands which are for the most part stony hill lands. In contrast a few trees - notably Ziziphus and Acacia as browse species and Tamarix and (more recently) a few Eucalyptus species as woodlot species - are carefully harnessed on private land.

3.1.3 A most encouraging development is the start of a nursery system for the production of tree seedlings, and this year an estimated 0.5 million will be issued. In addition Government has requested FAO to embark on a general survey of the country to assess its potential for forest development and to make plans for such development.

3.1.4 Another excellent development in the 'Communal Grazing, Forestry and Village Development' component is the proposed Livestock Development Project.\(^1\)

3.1.5 But much more could and should be done, making use of existing knowledge and proven species.

3.1.6 Eucalyptus is already used in local woodlots. The species in use is probably E. camaldulensis. This is satisfactory but other more drought tolerant and cold resistant eucalypts could be used and should be imported. E. camaldulensis grows under conditions of 380-1000 mm rainfall and 750-2500 m elevation, though Ethiopian experience shows vividly how different ecotypes vary in performance. Other eucalypts worthy of trial include E. viomonalis, which in CADDU trials has achieved a growth of 2.5 m in 20 months on a shallow soil and under low rainfall, and E. maidenii, which is one of the valuable honey producing eucalypts but requires a higher rainfall. Good millable timber is produced by E. regnans and E. delegatensis, though both of these require a higher rainfall than E. camaldulensis. Eucalypts for high country over 3000 m are E. dalrympleana, E. delegatensis, E. nitida and E. pauciflora.

\(^1\) 'Livestock development project' C M Chisholm & Associates (1975)
Cassia siamea is a fast growing and drought tolerant species which is good for poles and firewood and is not eaten by stock or termites. It is probably at its best in frost free zones. It is easily sown by harrowing in seed which has been scattered on the soil.

3.1.8 For combined woodlot and forage use (and honey production), there are several good species:

(i) Acacia nilotica subsp. indica, as found in the N Region of the Somal Republic (Bur'ao), is a very fast growing and drought tolerant species producing abundant pods of forage value, good quality camel browse and firewood.

(ii) Acacia cyanophylla is a tall shrub, drought and cold (but not frost) tolerant. It is an excellent browse species which withstands heavy pruning. It can be established by direct sowing of seeds pretreated with hot water or by transplants.

(iii) Parkinsonia aculeata is an ornamental which is also of use for fuel and fodder. In Ethiopia it is grown up to 2440 m elevation and under rainfalls of 1000 mm.

(iv) As a local species producing excellent timber, nutritious browse and an abundant honey flow, the sgl. Ziziphus spinocristata is unbeatable, but is seen at its best along wadi sides and in similar sites.

3.1.9 The best results with the above named species will be obtained on run-in areas and disused terraces, though the Acacia can also make growth on stony hillsides as long as care is spent in excavating the planting site, to give root space and provide a silt and water trap for each tree established.

3.1.10 But for abundant forage production on hillsides cactus (Opuntia) appears to be outstanding. There are many excellent examples of Opuntia ficus indica (some var. inermis and some var. amygdalifera) growing on the stony hillsides on which the local villages are built.

3.1.11 Cactus has many uses. It can produce abundant forage, say 30-150 t/ha under YAR highland and eastern dryland conditions. It is a producer of fruit, and its leaves may be used as a vegetable. In other low rainfall areas a combination of Opuntia and Atriplex salt bush has been found profitable, the higher protein content of the Atriplex balancing the productive but low protein forage of the Opuntia.

3.1.12 For the Montane Plains, cactus of the spineless variety, and other forage shrubs, could receive protection from a strong hedge planting of a spined variety such as O. ficus indica var. amygdalifera.
3.1.13: As there are many types of cactus and Atriplex it will be very important to introduce likely plant material for evaluation. In the meantime a survey of existing material should be made to identify the various types already in the country, and to obtain information on fruit and forage yields.

3.1.14: To make an impact, it is suggested that each village of the project area be examined and a woodlot-browse-forage planting programme drawn up. Such a study should identify suitable planting sites (including irrigable nursery sites), and would test the acceptance of such a programme.

3.1.15: Tree planting should be a most profitable long-term investment for emigrant workers who have large sums of money to invest. Eucalyptus planted on favourable sites should yield 125 heavy poles or 375 medium sized poles per incremental year after year 7 from planting. On present values a gross return of YR 500 he/annum seems possible. It is suggested that a scheme be devised to attract such investment and to channel it through agencies and cooperatives which could undertake the establishment of woodlots for the absentee villagers.

3.1.16: For communal tree planting efforts, WFP food aid might be obtained. Good results have been obtained elsewhere from such programmes.

3.1.17: Tihama.

3.2.1: An excellent species for planting on low-lying brackish lands is Conocarpus lancifolius (doma). This will grow right into the brackish salty lands with a high water table. It grows into a large tree; the wood of which is valuable for building construction and for boat building. The leaves are not browsed. Seed can be obtained from the Somali Republic, but as one or two young specimens are growing in the TDA compound they may provide an alternative source of seed.

3.2.2: For combined timber and forage use, there is Acacia nilotica, which may be seen growing in several situations on the coastal plain. There are many sub-species, and probably the one growing in the Tihama favours rather wet sites. A very drought resistant and productive type has been introduced from India to Somalia, and seed of this could be obtained from Bur'ao.

3.2.3: Selected shrubs of the large genus Prosopis should be of great use in the Tihama. Two types which grow under high water table conditions and with very scant rainfall are to be seen on the African coast: one, a tall-growing type, has been planted in the territory of the Afare and Issas, while the other has been planted along the coast north of Berbera in Somalia. The latter is probably Prosopis juliflora.
3.2.4 Prosopis and Conocarpus planted in large blocks on the leeward side of sand dunes may help in arresting their advance. Additionally, a spined cactus such as Opuntia ficus indica var. amyloca could be tried, as cactus has proved successful in dune stabilisation on the Somali coast.

3.2.5 As regards institutions and agencies for tree planting in the Tihamah, it would seem that TDA should take the lead and encourage village tree planting associations and individuals, as well as undertaking large scale plantings by direct labour or contract. The use of WFP food assistance should also be considered.

4. BEE KEEPING

4.1 Yemen and South Western Arabia in general, is famous for its honey. There may have been some decline recently, since local honey is now a very expensive item (YR 60 per pint bottle) and imported honey is now seen in quite remote areas. Reduction in honey production will have followed the decline of the honey-producing vegetation, and this is something that has to be arrested. In addition drought years may have reduced bee colonies and recovery has not yet been made.

4.2 Increase in the honey flow will follow the proposed tree and browse plant establishment. In addition, improvements in hive construction may be worthwhile. An improved hive of easy construction is the Kenya Top Bar hive within which is placed a queen bee excluder. Trial and demonstration of this improved hive would be worthwhile.

4.3 This subject is so important that it is suggested that a bee keeping expert should be brought in to survey the whole bee keeping industry and make recommendations for improvement.

5. PROSPECTS FOR LIVESTOCK DEVELOPMENT

5.1 Cattle

5.1.1 The highland type short-horned zebus are excellent triple-purpose beasts.

5.1.2 When adequately fed they may be expected to give 500-600 litres per lactation (not 250 litres as has been suggested in the Chisholm report, op.cit.). Crossed with a high quality Friesian, the progeny should give 1500-1700 litres per lactation.

5.1.3 Notwithstanding this milk potential, the main objective in cattle production in the whole of the YAR is the raising of draught oxen on which the arable system largely depends.
For this reason care must be taken to see that breed improvement aimed at producing more milk does not interfere with this objective. First or second cross Friesian x local zebu will be quite satisfactory for the plough, but their feed requirement will be doubled and implements would need to be altered to suit the increased draught power and the size of the animal.

5.1.4 The local zebu also produces a respectable carcass and average quality beef when properly fed. However, it is mostly cull oxen that are slaughtered and most slaughter stock (those that are not imported) come from the Tihama. For the present, therefore, there seems more potential for dairy development. Milk for the main cities and towns could come from town dairies or nearby dairy units. High grade stock can be used in the highlands. On the Tihama, one-cross Friesian x zebu will produce stock quite suitable for the climate, though the second cross should be with a high quality Sahiwal.

5.1.5 The use of artificial insemination for both the up-country and Tihama herds should be investigated. Bull stations using heavy 800 kg bulls on small local cows are not very successful.

5.2 Sheep and Goats

5.2.1 The best opportunity for improvement lies with this class of livestock. In the Montane Plains, the existing depleted range vegetation already carries a light stocking of 'sheep', while planting of browse and forage species, including Cnuniea and Atriplex, would provide forage for much increased production.

5.2.2 However, no worthwhile increased production can be expected unless forage tree and browse production goes forward.

5.2.3 Breed improvement can be brought about by selection within the local flocks and by the introduction of suitable exotic stock for use in grading up the local breeds.

5.2.4 Breed improvement associations might be formed to undertake the registration of flocks and to identify the most productive breeding females in these flocks. Retention of rams and bucks would then be from the most productive females. After a period elite stocks can be identified, and then the ram, circle system can be applied to move superior breeding sires from the home flock round to other flocks. From such superior breeding stocks, livestock stations might acquire special stud breeding animals. The proposed livestock stations will have an important function in introducing and evaluating exotic breeds.
5.2.5 It is suggested that the following breeding stock are imported:

(a) **Sheep for the Montane Plains:**

(i) *Awassi* from Yugoslavia and possibly Syria or Lebanon if selected stocks can be obtained there. The specialised *Awassi* milk strain should be imported. Production level should be 200 kg/lactation.

(ii) *White Karaman* from Turkey, where there are large government flocks. The Karaman is a good triple purpose sheep. Average milk yields under range conditions are 60 kg/lactation, while the carpet wool clip is 1.8 kg a year. Ewe weight is 60 kg.

(b) **Goats for the Montane Plains:**

Goats seem to have gone out of favour because of caprine pleuropneumonia, but good milking goats can really help solve the problem of milk supply in the highlands. It is suggested that high quality *Saanen* goats should be brought in for trial. Production levels should be at least 500-600 kg/lactation. (The Kenya Range Project imported a very good strain; it may be possible to obtain a few of these).

(c) **Goats for the Tihama:**

Goat breeds for improvement in the Tihama are the *Junnapari* from the Indian sub-continent and the *Nubian* from SE Sudan. There is also an improved Anglo-Nubian high yielding type, but it is doubtful if this would be adapted to the heat of the Tihama.

5.2.6 Returning to sheep, it would appear that the local *Dhamari* sheep are of the Danakil 'Afar type. The origin of this local type is obscure but it is almost certain that it originated from a mob of sheep brought in for slaughter. The *Dhamari* appear to be good sheep but an improvement in milk yield should be possible with the introduction of selected 'Afar stock, since the 'Afar stock are almost certainly better milkers. This could be arranged in due course through the NE Rangelands Project of Ethiopia.

5.3 **Camels**

5.3.1 Camels also serve as multi-purpose animals. They are common in both the highlands and the Tihama. It seems that breeding stock are maintained in the highlands as well as in the lowlands but that new blood is introduced periodically from the eastern lowlands of the YAR.

5.3.2 Camel production in the Montane Plains may be expected to increase as the forage tree and browse shrub planting programme gathers momentum. The use of camels to harvest the 'top feed' from the taller browse shrubs will be an economic means of management of these plantations.
are also the one domestic animal able to effectively browse the spined varieties of cactus, which may be used as stock fenc/hedge material to protect spineless cactus and Atriplex or other browse shrub plantations.

5.3.3 The possibility of hiring-in burden camels for seasonal work on the Montane Plains may be the means of reducing the work oxen force which is so demanding of forage not produced on the rangelands. Camels maintained in good condition by nutritious browse feed produced on dry-land areas might perform all tillage operations other than very heavy ploughing. Forage from crop lands should then be available to provide more feed for the remaining work oxen and for other classes of livestock.