A MANUAL OF ECODEVELOPMENT WITH SPECIAL REFERENCE TO THE WESTERN GHATS

Edited by
MADHAV GADGIL
PRABHAKAR R. BHAT

Centre for Ecological Sciences
INDIAN INSTITUTE OF SCIENCE

and

K. M. HEGDE
Sahyadri Parisara Vardhini
Yadahalli, Taluk Sirsi
District Uttara Kannada-581 340
Karnataka

CENTRE FOR ECOLOGICAL SCIENCES
Indian Institute of Science
BANGALORE - 560 012
INDIA

Preface

This manual is a preliminary attempt to provide a sketch of the motivation for and content of the ecodevelopment approach. Being a first attempt, we have been able to provide relatively full details for only a few of the relevant aspects, namely enhancing the plant cover and fuel conservation. We have, however, tried to provide a reasonably complete overall framework and it is our hope that we shall in due course be able to fill in these gaps and come up with a comprehensive manual which may be of some value to all involved in such an effort, especially the educational and scientific institutions and the voluntary agencies.

Deepavali, 13th November 1985

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1. THE CHALLENGE OF DEVELOPMENT

(Madhav Gadgil)

1.1 It is nearly four decades of independence since India launched on a path of social and economic progress. Mindful of how we had been exploited by being converted into an industrially backward, stagnant economy, we resolved to catch up with the industrialized West through deliberate, planned effort. Thirtyfive years of this endeavour has yielded rich dividends. We are now a nation with a strong industrial base, substantial scientific and technological capabilities and good transport and communication facilities. We have eradicated the spectrum of epidemic diseases, and have succeeded in stepping up our agricultural production manifolds.

1.2 The Western Model

Yet there is little room for complacency. In fact, there is every indication that we have committed serious errors in our choice of the path to economic development; a choice based on an imitation of the Western model. The Western civilization surged ahead of us in the late eighteenth century with discoveries such as the steam engine and the use of coal in the manufacture of iron. These abilities to tap the energy of fossil fuels with great efficiency and to fashion new materials thereafter grew at a rapid pace as the West developed the technique of a link-up between the growth of scientific knowledge and its practical application. The result was the industrial revolution, grounded in a much more intensive use of the resources of the earth. The advantage that this conferred on the Western Civilization enabled it to dominate the rest of the globe with all its resources. In its euphoria of conquest of the world and technological progress, the west all but forgot that resources of the earth are finite and must be accounted for. Their economists taught that economic progress was constrained only by inputs of labour and capital.

This march of the Western civilization was initially characterized by great human tragedies. The life of the

labour class employed in the factories and mines of the eighteenth and early nineteenth century was miserable, far worse than that on the farms from which they had been driven off. Much worse still was the treatment meted out to the people of the conquered continents. In Americas, the Red Indians were exterminated, in Africa the blacks enslaved and in Asia the native craftsmen brutalised. But as time progressed, the labour class in the Western nations gradually came to share in the growing prosperity; though the bulk of the people in the non-Western nations never came to do so.

1.3 Two Flaws

A facile reading of the progress of the Western nations therefore gave rise to the notion that all that was needed was economic growth rooted in industrial and technological progress. That once this was achieved, the resultant prosperity would automatically percolate to all segments of the society, and that resources would take care of themselves. It is such a flawed model of economic development, that has led us to our current, difficult situation. For, in reality, there are genuine resource constraints, and the benefits of development hardly ever percolate to the weaker segments of the society without special effort. In fact, the industrial nations are themselves beginning to experience such resource constraints more and more, despite their colonization of much of the world and access to the resources of the rest. Thus, United States has regrown its forests while drawing on the timber of Indonesia and Amazonia. But the spectre of acid rain is now threatening to wipe these out. The Western nations have also made special efforts to ensure that the fruits of economic growth reach all segments of the society, be they in the form of communism of the Eastern Europe or the welfare state of the Western Europe and United States.

2. OUR DWINDLING RESOURCE BASE

(Madhulika Sinha and Madhav Gadgil)

2.1. The Indian model of development, thus grounded in scant regard for depletion of the capital of natural resources and little concern for ensuring that benefits of development percolate to the weak and the poor was bound to lead us into difficulties. That these difficulties are only dimly perceived as yet arises from the near total neglect of proper monitoring of the resource base. We have therefore attempted to provide a sketch of the true state of affairs by pulling together as much information as possible for the state of Karnataka. This information derives from a number of sources; the State Bureau of Economics and Statistics, the state Departments of Agriculture, Forest, Animal Husbandry and Veterinary Services, the National Sample Survey, the University of Agricultural Sciences, Bangalore and the field studies of Ungra village in Tumkur district by the Cell for Application of Science and Technology to Rural Areas (ASTRA) and of Unchagi and some other villages in Uttara Kannada district by the Centre for Ecological Sciences, both at the Indian Institute of Science, Bangalore. We have also used Handbooks and other publications of the Indian Council of Agricultural Research and the Indian Council of Medical Research in making various interpretations. As the full technical details will be published seperately, we shall here confine ourselves only to the major conclusions.

2.2 Environmental Regimes of Karnataka

Our primary concern is the renewable resources, namely soils with their nutrient reserves, water, vegetation, both of cultivated and uncultivated lands and the domesticated livestock. The state of Karnataka fairly naturally falls into six zones in relation to these factors (Fig. 2.1).

The first is the coastal zone with coastal alluvial and lateritic soils receiving a rainfall of around 3500mm a year over 6-7 months. It is characterized by the highest population densities in the state of 440 persons per Km^2, moderate livestock densities of 1.07 per hectare with livestock dominated by cattle (81%) and buffaloes (17%). There are extensive tracts of barren hilly lands in this zone; the main cultivated plants being paddy, coconut and cashewnut.

The second zone is the low lying stretch of Western Ghats of Uttara Kannada district ranging in altitude from 300 to 600 m. It is a zone of lateritic soils receiving an annual rainfall of about 2500 mm over 6-7 months. It has the lowest population density in the state of 82 persons per Km^2, as well as the lowest livestock density of 0.49 per hectare. The livestock is primarily cattle (77%) and buffaloes (19%). There are extensive stretches of this tract under forest, while the main crops are paddy, arecanut and coconut.

The third zone of the state is the crestline of the Western Ghats to the south of Uttara Kannada with altitudes

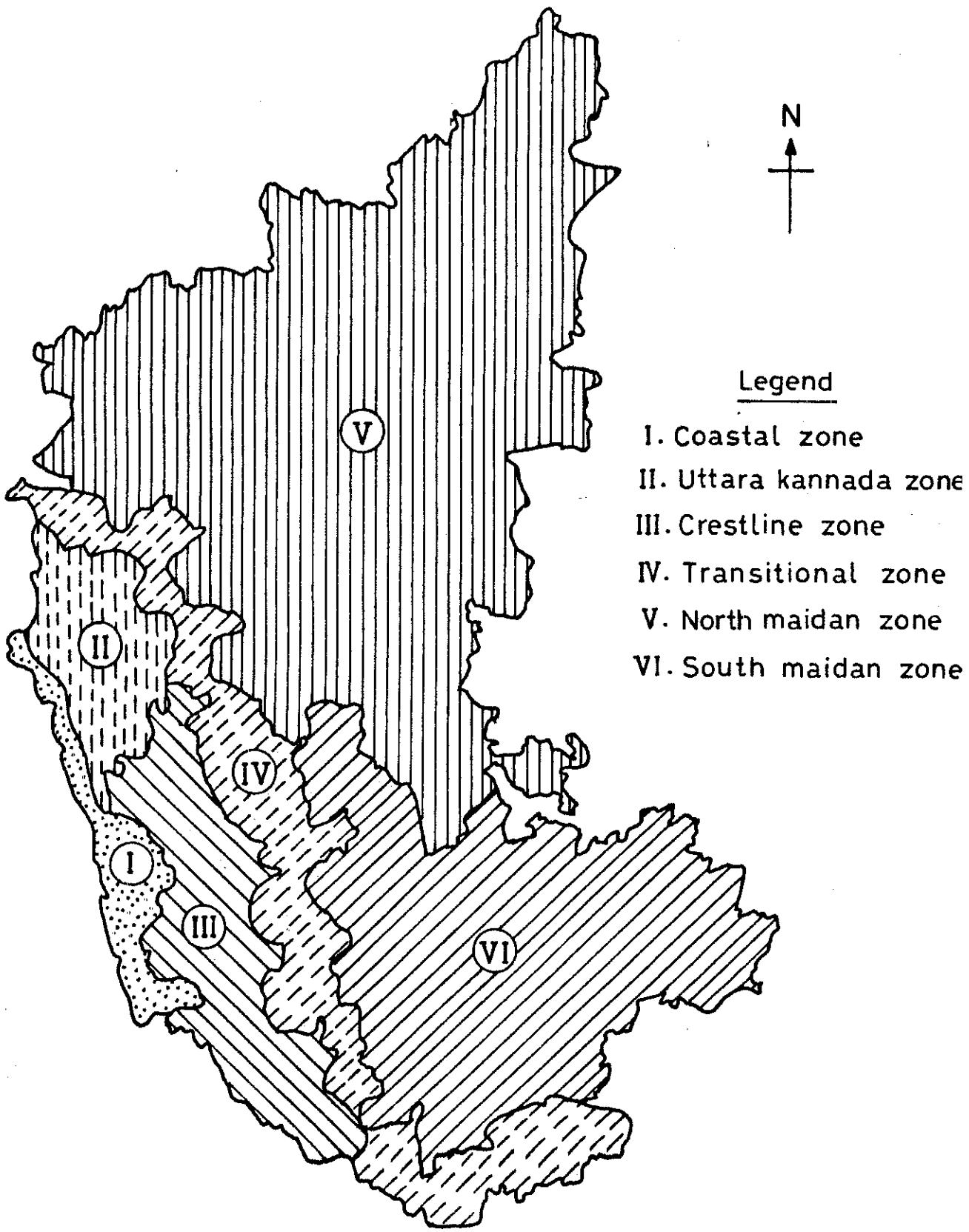


Fig. 2.1 Different ecological zones of Karnataka.

generally in the range of 600 to 1350 m. It has lateritic and red loam soils and the second lowest population density of 125 per Km^2. It also has a fairly low livestock density of 0.81 per hectare with 76% of cattle, 18% of buffaloes and 6% of goats. There are extensive forested lands and tea, coffee and spice plantations as well as substantial cultivation of paddy.

The fourth zone stretches all the way from north to south just to the east of the Uttara Kannada and crestline zones. It represents a region of transition to the Deccan plateau and lies at an altitude of 600 to 700 m. It receives an annual rainfall of 2000 mm spread over 6 to 7 months and has a mixture of red loam and black soils. It has a relatively high density of human population as well as livestock populations at 190 per Km^2 and 1.22 per hectare respectively. The livestock is made up of 64% cattle, 13% buffaloes, 9% sheep and 14% goat. The main crops are paddy, ragi, jowar and groundnut; there is a moderate extent of forested lands in this zone.

The fifth zone of the state is the northern maidan areas of Deccan plateau ranging in altitude from 300 to 900 m with a low and highly variable rainfall with an average of 668 mm a year. There is a long dry season of 8 months. The soils are black cotton soils and the main crops are jowar, cotton and groundnut with sugarcane in irrigated areas. The region has a medium population density of 147 per Km^2 and a medium livestock density of 0.84 per ha.

Sheep and goat make up 45% of livestock. There is almost no forest in this plains tract.

The sixth region of the state is the southern maidan zone with many ranges of low hills; the altitude ranging from 600 to 900 m. The rainfall is low; on an average 744mm a year and confined to 4-5 months. The soils are red sandy and red loams. There is a relatively high population density of 283 per Km^2; as well as a relatively large livestock population of 1.5 per ha. The latter ~~has~~ includes 44% of sheep and goats. The main crops are paddy, ragi and pulses; and there is little forested land.

2.3 Food Production

The sown area of the state varies from a low of 10.7% in the largely forested Uttara Kannada hill zone to 63% in the southern maidan zone. For the state as a whole the sown area is just about half of the total land. Of this about 14.3% is under irrigation. Out of the total 9.5 million hectares under cultivation, 6.3 million hectares is under cereal grains and 0.77 million hectares under pulses. The total annual pulse production of the state averages 3.5 lakh tonnes, the cereal grain production 103 lakh tonnes. With a population of 370 lakhs, this implies a per capita grain availability of 695 grams per day and pulse production of 25.9 grams per day. Converting these into calorific and protein terms this amounts to an availability of 2400 kilocalories and 55.6 grams of protein per person per day

from cereals and 89.5 kilocalories and 6.54 gms of protein per person per day from the pulses. To this must be added a certain smaller quantities of kilocalories and proteins from milk, fish, meat and vegetables. Now an adult male requires a total of 2800 kilocalories and 50-55 gms of proteins every day. Given that there are a substantial proportion of younger children and women in the population, the state is just about self-sufficient in food. (Fig.2.2 a tod)

This analysis, however ignores two complexities. Firstly, food production is not equitably distributed over all the six regions of the state. In particular, the grain production amounts only to 311 gm/ of grain per person per day in the thickly populated coastal tract; being clearly inadequate. For more importantly, a large proportion of the state's population does not earn enough to buy adequate quantities of food even though these may be available. A recent careful study based on the last two National Sample Survey rounds by Dr. P.J. Nayak and Dr. Gladys Sumithra suggest that in 1983 fully 66.7% of Karnataka's rural population and 82.2% of its urban population did not earn enough to purchase sufficient food to ensure adequate nutrition.

2.4 Fuel Consumption

Not only must food be available in sufficient quantity, it must be cooked. With 500 gms of grain, plus some pulses and beverages, this implies the daily requirement of 0.84 kg

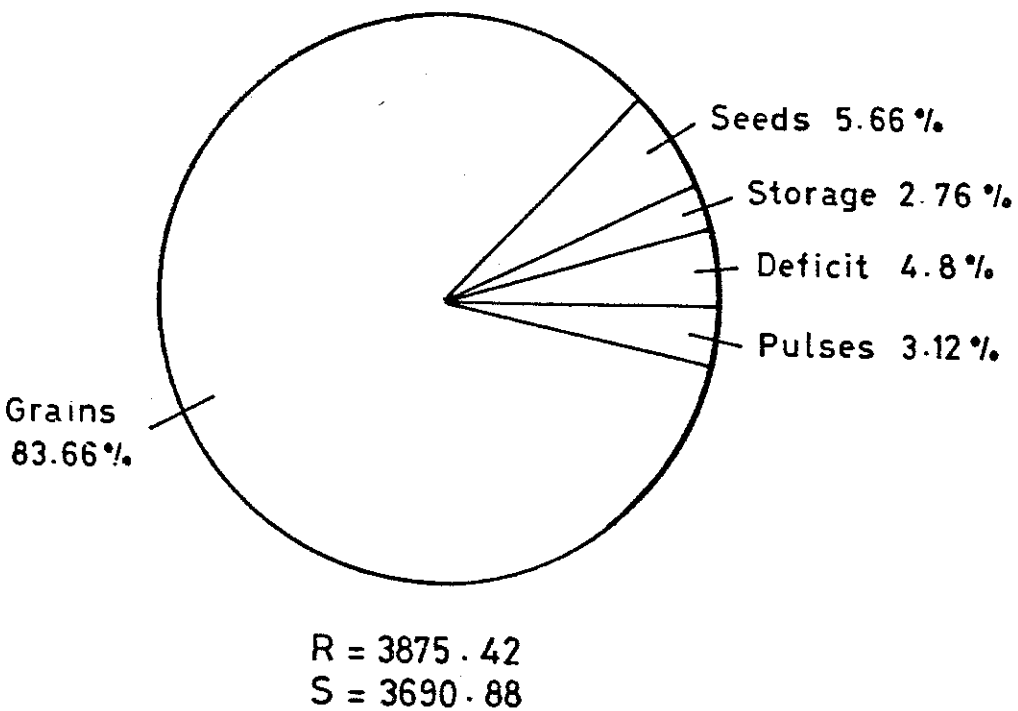


Fig. 2.2a Estimated calorific requirement (R) and supply (S) from grains and pulses in Karnataka (K.cal 10^{10}).
(Average calorific requirement per capita 2800 K cal)

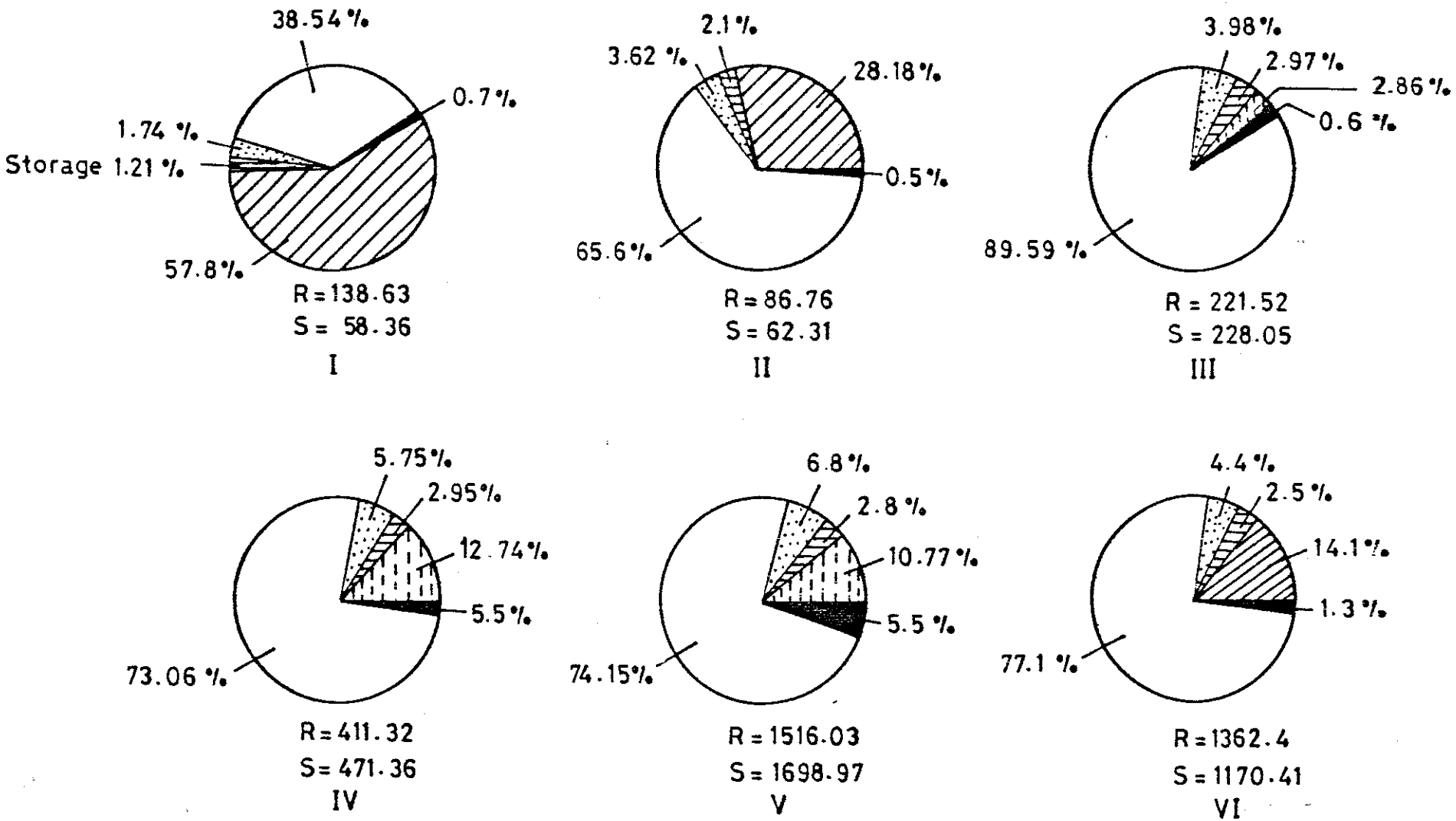


Fig. 2.2b Estimated calorific requirement (R) and supply (S) from grains and pulses in the different zones of Karnataka (K cal. 10^{10})

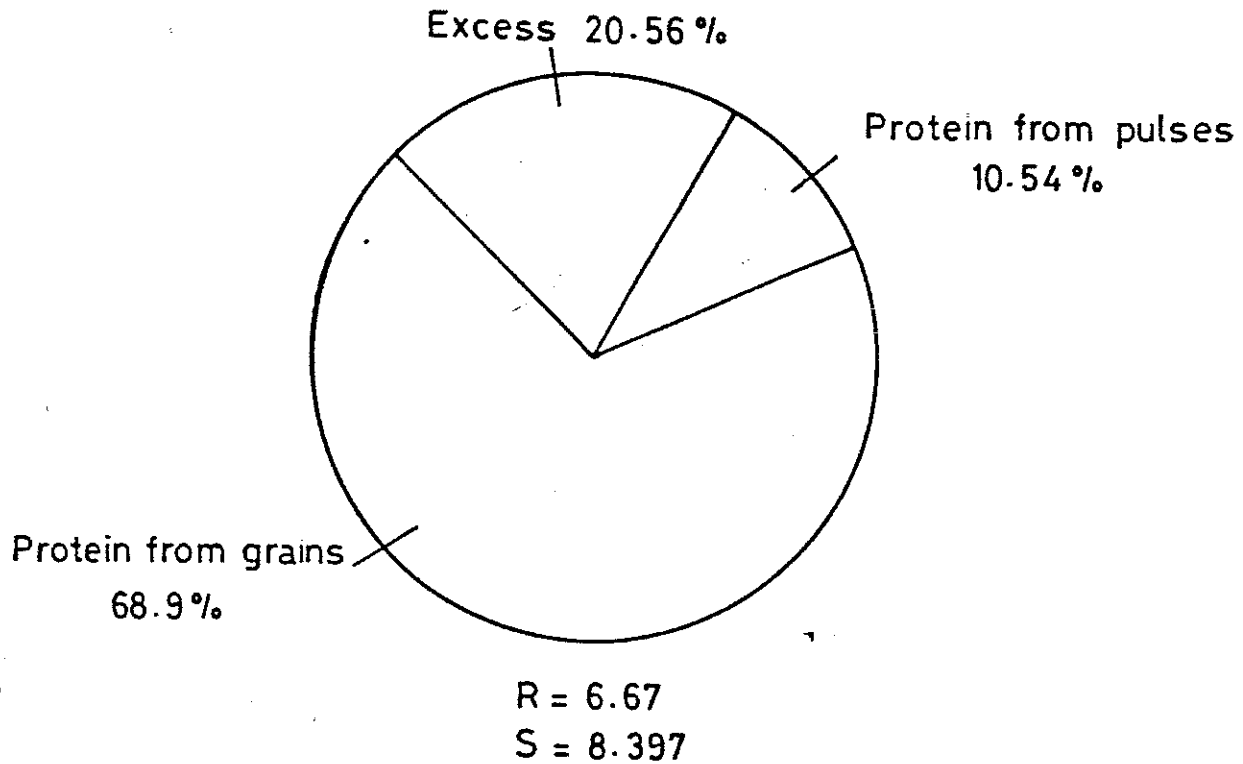


Fig. 2.2c Estimated protein requirement (R) and supply (S) from grains and pulses in Karnataka (lakh tonnes)
(Average protein per capita requirement = 50 gms)

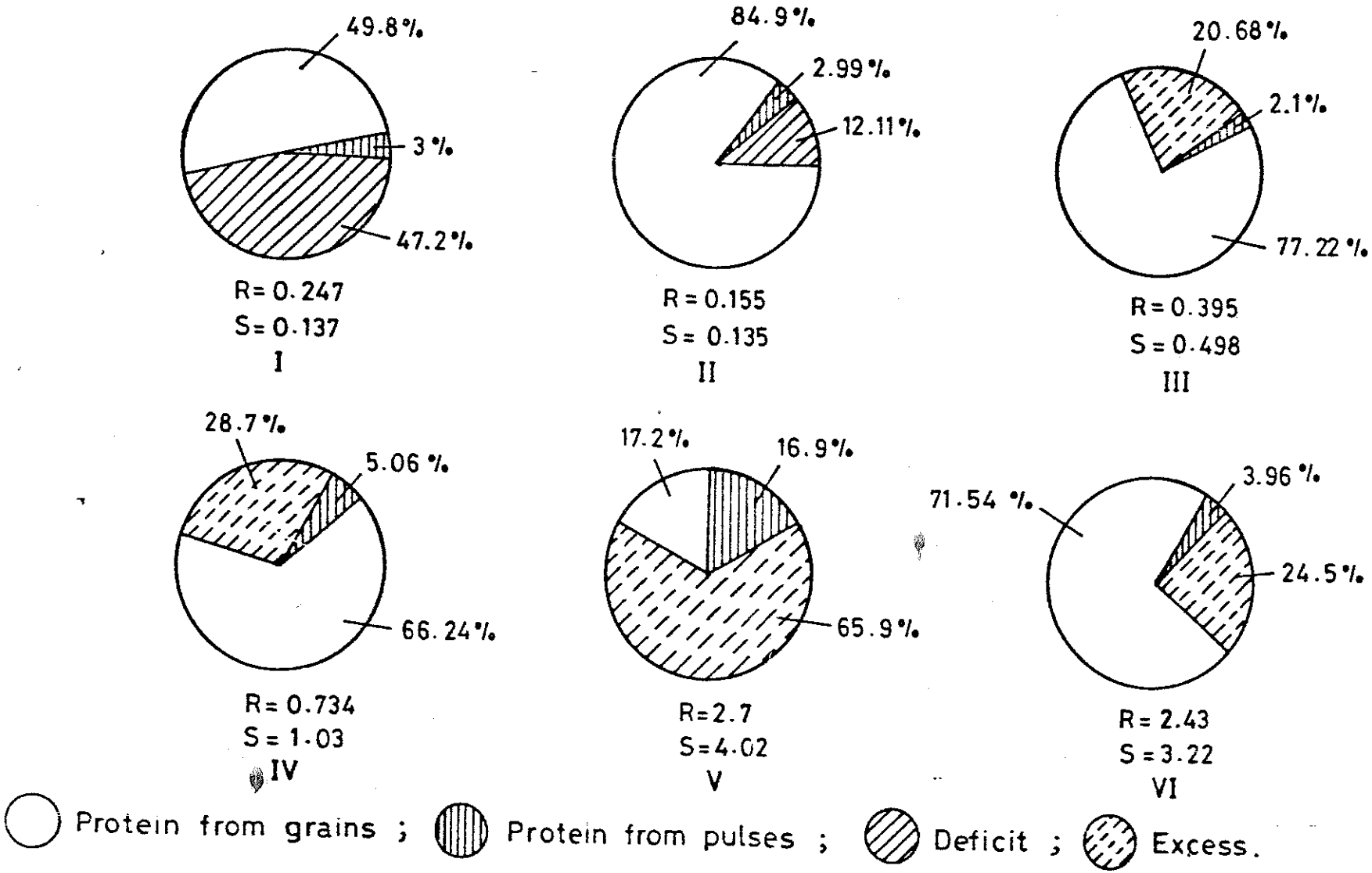


Fig. 2.2d Estimated protein requirements (R) and supply (S) from grains and pulses in the different zones of Karnataka (lakh tonnes) (average protein per capita requirement = 50 gms)

of fuelwood (or its equivalent) per day given the current efficiencies of the woodstoves. Part of the demand for cooking energy in Karnataka state is met by other sources such as kerosene and electricity; however, according to the NSS data this amounts only to 36.5% of fuel needs of the urban and 17.2% of the fuel needs of the rural population. All the other cooking is done either with fuelwood or failing that dung. This implies an annual requirement of 85 lakh tonnes of fuelwood for the state for cooking purposes alone. There are additional domestic demands, for water heating etc. This totals, according to NSS data, to an annual demand of 112 lakh tonnes of fuelwood for Karnataka.

A substantial part of this demand is met through burning of agricultural wastes, especially coconut shell, coconut and arecanut leaf rachis, groundnut shells, paddy husk and cotton sticks. The following is a picture of total annual supply of fuel as agricultural wastes in relation to total annual demand ~~for cooking purpose alone~~ for the various zones. The figures are in lakhs of tonnes.

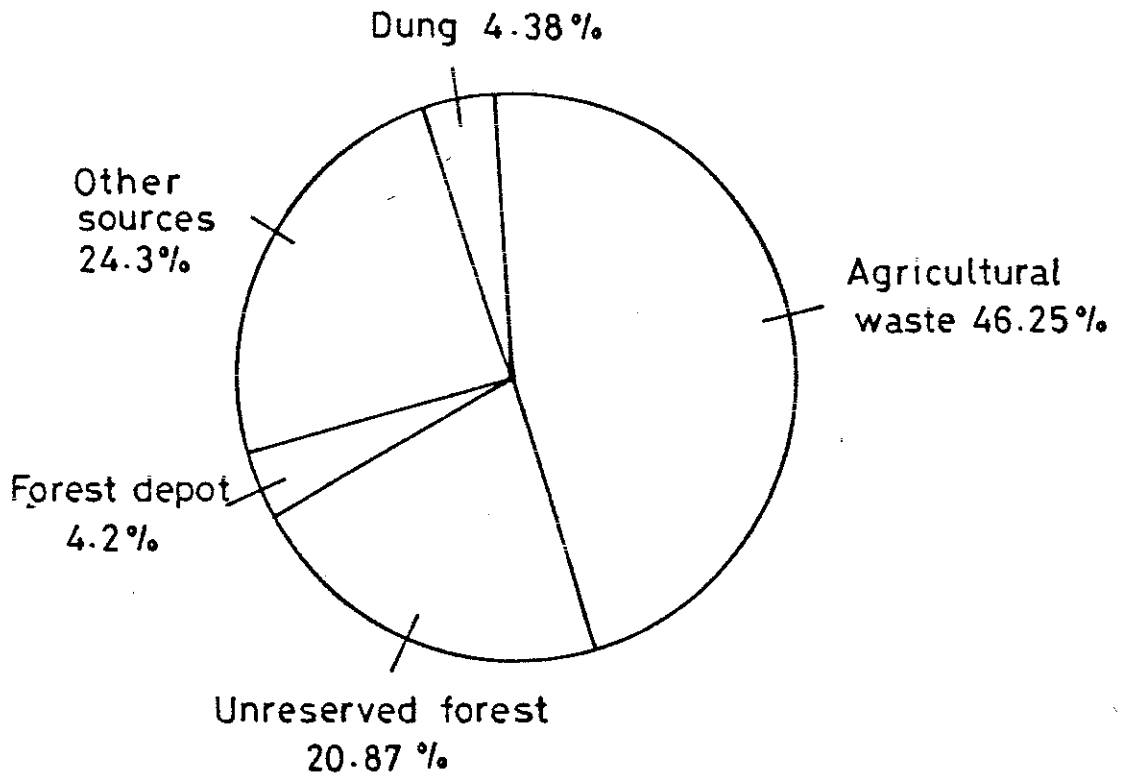
ZONE	I	II	III	IV	V	VI	Entire State
Agricultural wastes	0.6	0.74	3.9	4.28	32.48	9.86	51.9
Total fuel wood needs	4.16	2.6	6.64	12.34	45.5	40.87	112.22

Table 2.1

It can be seen that agricultural wastes meet less than half the fuel needs of the state as a whole as well as in every zone except the northern maidan zone. In this zone of black cotton soil, cotton sticks provide a very substantial input towards meeting fuel needs. Part of the fuel demand is met by fuel supplied from the forest department depots. However, this makes only a small contribution of 5 lakh tonnes or so. This leaves a deficit of 50 lakh tonnes; about 10% of this deficit, namely 5.5 lakh tonnes is met from dung, especially in the third to sixth Zones. The remaining 45 lakh tonnes is required to be met from 11.8 lakh hectares of protected, unclassed, village and private forests. This imposes a demand of 4 tonnes/ha/year. Now total annual above ground wood production of natural vegetation in Karnataka would range from 4 to 8 tonnes/ha depending on the rainfall if this vegetation is well protected. Unfortunately, this is far from the case and under its present depleted condition, and with the present grazing pressures, this production must be of the order of 0 to 6 tonnes at most; with an average around 1.5 to 2.0 tonnes. This implies an overexploitation by a factor of two or more, leading to a progressive degradation of the vegetation. This indeed is seen to be the case; and much of this so-called wasteland of the state is getting continually depleted (Fig. 2.3 a and b)

2.5 Fodder Consumption

The state has an enormous livestock population of nearly 99 lakh cattle, 31 lakh buffaloes, 42 lakh sheep and



Domestic fuel requirement = 112.22 lakh tonnes

Fig. 2.3a Estimated fuel availability in the state.

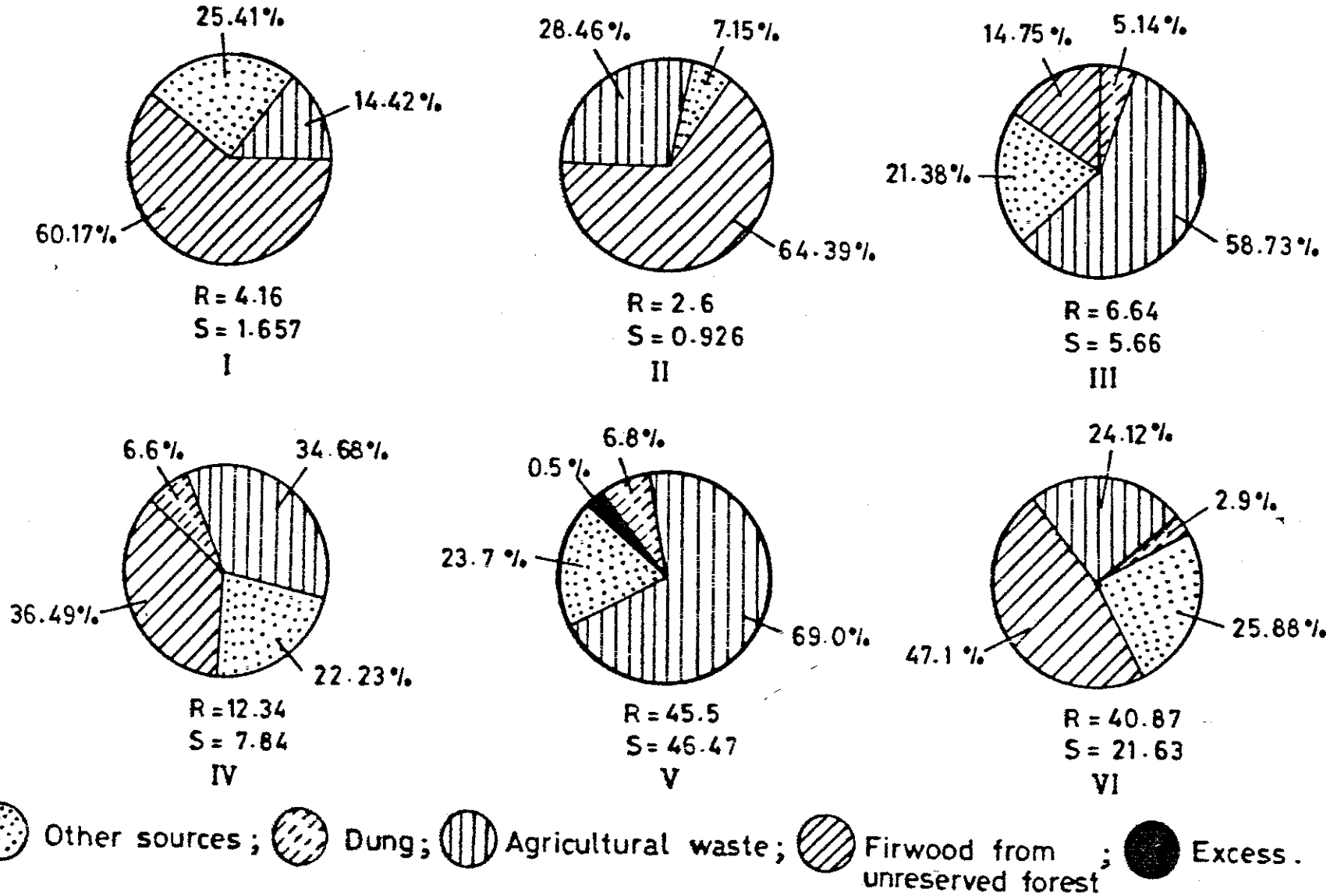


Fig. 2.3b Estimated cooking requirement (R) and supply (S) of fuel in the different zones of the state (Lakh tonnes)

ZONE	I	II	III	IV	V	VI	Entire State
Total fodder demand (lakh tonnes)	7.38	11.37	31.33	46.48	168.02	146.92	411.51
Straw (lakh tonnes)	2.04	2.22	6.76	15.23	32.13	35.57	93.94
Other fodder from agriculture (lakh tonnes)	0.14	0.11	1.56	1.80	12.47	4.87	20.95
Molasses (lakh tonnes)	0	0.02	0.02	0.07	0.76	0.61	1.47
Oil cake (lakh tonnes)	0	0.01	0.01	0.25	2.31	0.42	64.51
Demand unfulfilled from cultivation (lakh tonnes)	5.2	9.01	22.98	29.13	120.35	105.45	230.64
Land uncultivated (lakh hectares)	.97	.489	6.04	4.16	16.8	11.56	40.1
Reserve forest (lakh hectares)	0.67	8.3	5.52	5.81	8.32	3.21	31.8

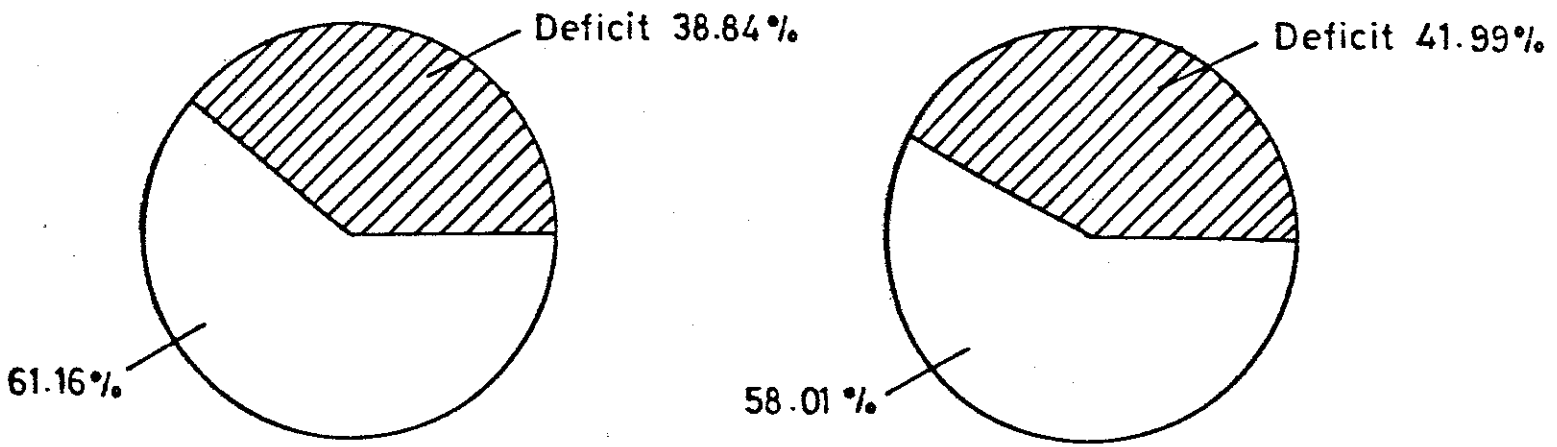
Table 2.2

35 lakh goats. These vary in size, depending on the Zone in which they occur; being short in the high rainfall zone and much bigger in the maidan tracts. Taking into account this size variation, and using a rule of thumb of 2.5 kg of dry weight of fodder needed per 100 kg of animal body weight, we have worked out the fodder requirements of the state's livestock which comes to over 411 lakh tonnes. This is met from two sources; the grazing which is available on fallow, uncultivated and forest lands and from the stalks of cereal

crops along with oil cakes, molasses and other agricultural by products. Given our rainfall pattern, grazing on waste and forest lands is by and large confined at most to the months of May to October; the fodder requirements for the other six months must be met from cultivated land. The production of fodder on waste and grazing lands may range from 1 to 2.5 tonnes per hectare depending on rainfall; under heavy overgrazing it may be even less. (Fig. 2.4a-c)

On these assumptions 3.7 lakh tonnesof fodder must come from grazing on 1.64 lakh hectares of uncultivated land in the first Zone; this is possible. But of the balance 3.7 lakh tonnes, only 2.18 lakh tonnes is available from agricultural production. In Zone two, 5.7 lakh tonnes must come from 8.79 lakh hectares of uncultivated land; mostly reserve forest. Again this is possible; but of the balance of 5.7 lakh tonnes which must come from cultivation, only 2.3 lakh tonnes is available. In Zone 3, 15.7 lakh tonnes of grazing must come from 11.56 lakh hectares of uncultivated land; this is feasible; but the cultivated lands provide only 8.6 lakh tonnes of the needed 15.7 lakh tonnes. In these three Zones then there is reasonable availability of grazing in the wet season; but acute shortage in the dry season.

In the other three Zones, and in particular the two maidan Zones there are scarcities in both the wet and dry season. In the maidan Zones less than a third of the fodder requirement is met by cultivated land; while the



R = 205.75
S = 125.82

May to October
(Uncultivated lands)

R = 205.755
S = 119.36

November to April
(Agricultural waste)

Fig. 2.4a Fodder requirement (R) and supply (S) in Karnataka (lakh tonnes)

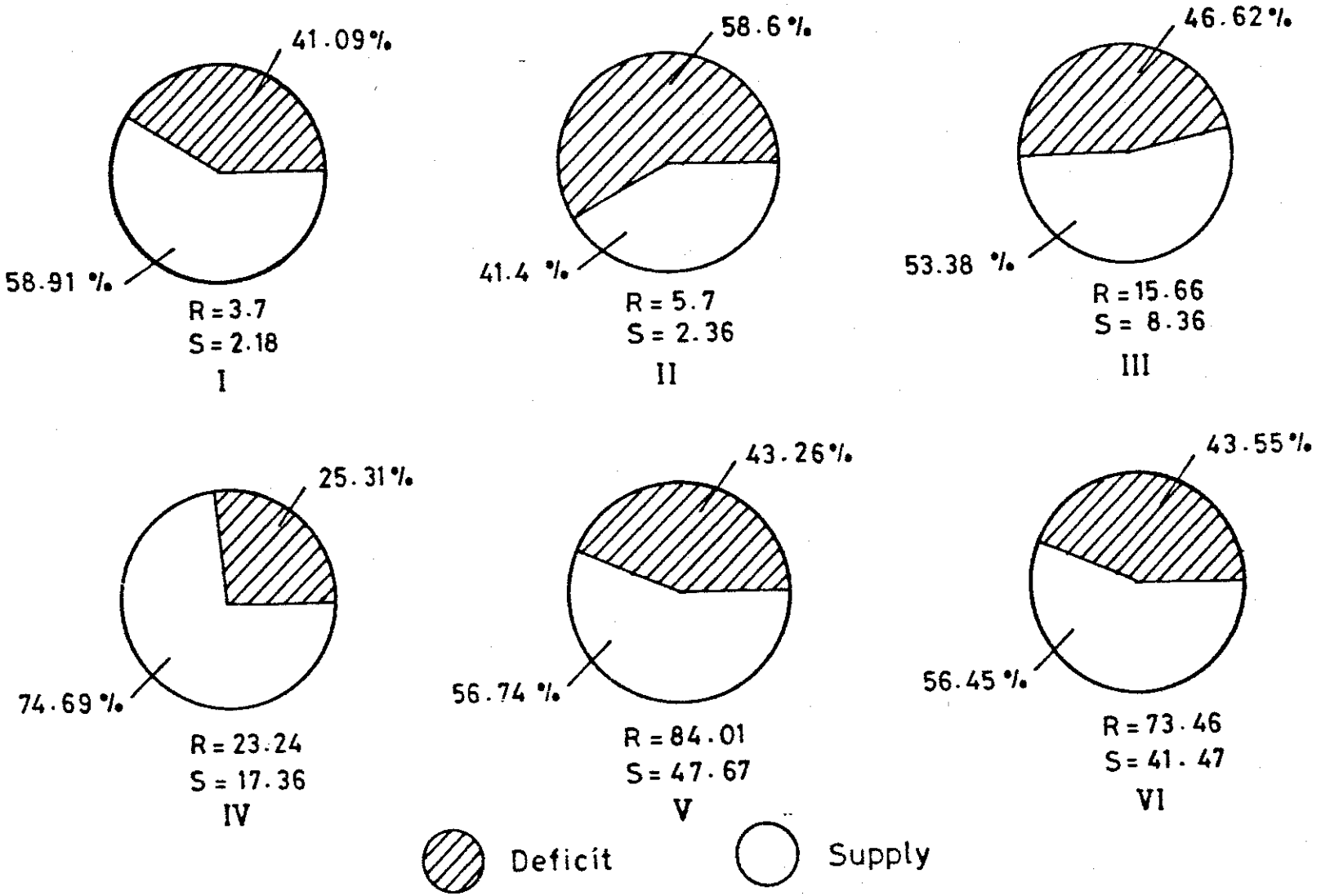


Fig. 2.4b Fodder requirement (R) and supply (S) from agricultural wastes during November to April in the different zones in Karnataka (Lakh tonnes)

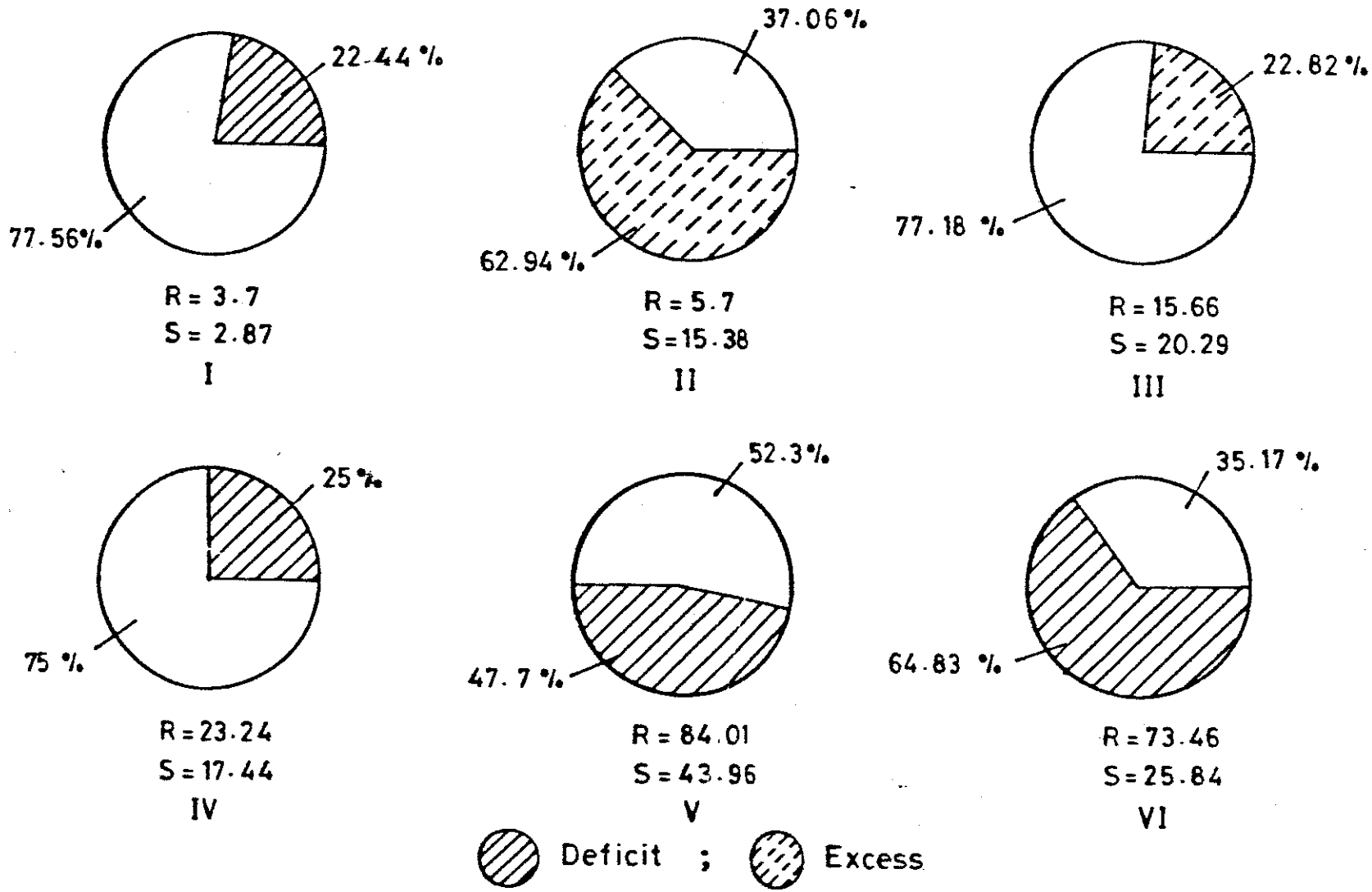


Fig. 2.4c Fodder requirement (R) and supply (S) from uncultivated lands during May to October in the different zones in Karnataka (Lakh tonnes)

uncultivated lands are so inadequate as to meet as at best another third of the requirements. This must imply that animals are almost totally on a starvation regime in the latter half of the dry season. The maidan regions are also tracts of very erratic rainfall, and the situation becomes all the more difficult in years of scanty precipitation.

All over the state then the situation that prevails is one of exhaustion of fodder from cultivated land, simultaneously with complete drying up of natural grass growth in months of February to April. When thus desperate, the animals will graze on anything and everything, damaging in this process all chances of regeneration of tree growth. In this season, the villagers also set fires everywhere, hoping to stimulate some fresh growth with the early pre-monsoon showers. These fires further damage young tree growth and seedlings and saplings.

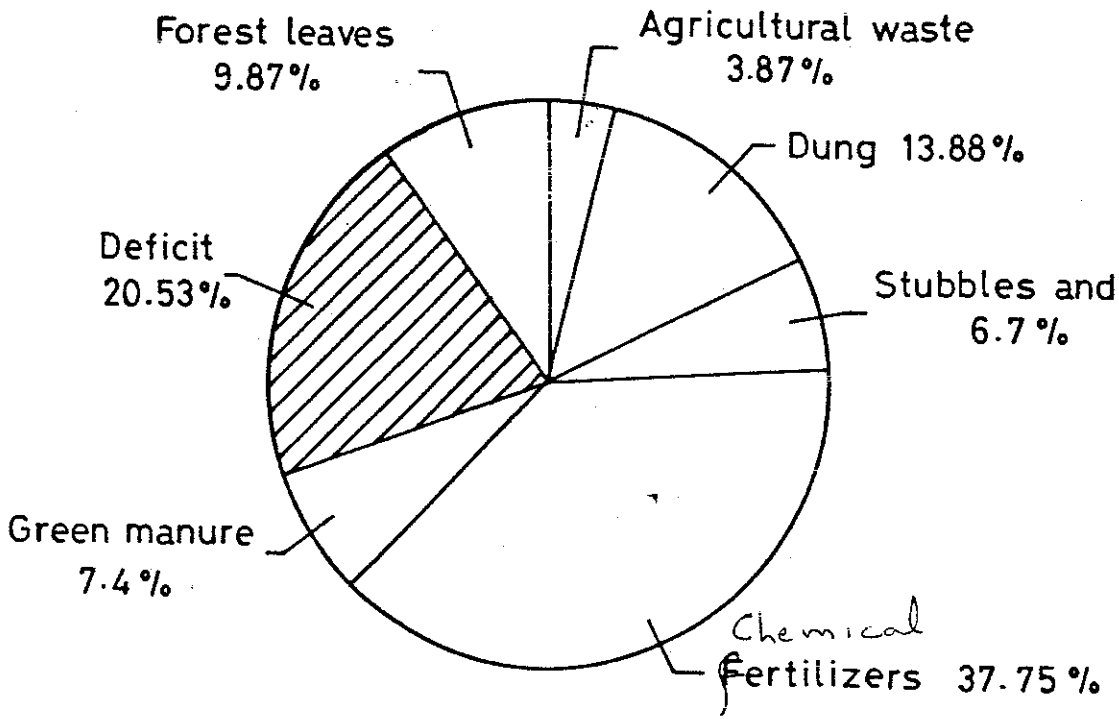
It must be noted that with fodder thus insufficient some 7 lakh tonn of it has to be diverted to thatching huts and cattle sheds.

2.6 Manure requirements

Aside from fuel, fodder and shelter, a major demand on plant biomass is for use as manure to replenish the nutrients removed from the soil through harvest of grain, cotton, nuts and other produce. It is imperative that the nitrogen, phosphorus and other nutrients thus taken out

must be replenished by the use of chemical fertilizers as well as organic manure.

As an illustration let us consider the nitrogen budget of the state's cultivated land. Our calculations indicate that harvests lead to a removal of 2.44 lakh tonnes of nitrogen from land under cereal grains and another 3.23 lakh tonnes from land under other crops. As against this a total of 2.14 lakh tonnes is returned through chemical fertilizers leaving a balance of 3.53 lakh tonnes. This is met partly by roots and stubble left standing in the crop, to the tune of 0.38 lakh tonnes, and other agricultural wastes including decomposed thatch to the tune of 0.22 lakh tonnes. But the bulk was traditionally returned by dung and leaves brought from the surrounding forest lands. Now the over 200 lakh animals of the state are expected to produce some 64 lakh tonnes of dry weight of dung. Assuming that 80% of this is converted to manure, this would provide about 0.8 lakh tonnes of nitrogen. Let us also assume that about 3 tonnes of leaves are removed per hectare from the 11.73 lakh hectares of unreserved forest. If so, this would provide 0.56 lakh tonnes of nitrogen. In addition, a total of 0.42 lakh tonnes of Nitrogen are returned through the cultivation of leguminous green manure crops. With all these, rather generous estimates, the total returns are 4.5 lakh tonnes as against a harvest of 5.67 lakh tonnes(Fig 2.5). The clear implication is a continual loss of soil fertility.



N_2 removed from soil = 5.67 lakh tonnes

N_2 returned to soil = 4.50 lakh tonnes

Fig. 2.5 Estimated nitrogen balance of the state.

This is a grave problem, which needs serious attention. Apart from this overharvest of nitrogen, much land is being rendered unproductive by salination due to excessive irrigation without proper drainage. Thus not only are we squandering away the plant biomass of uncultivated lands, we are also losing the productivity of our precious farmlands. Time has clearly come to rethink our entire strategy of management of the state's natural resources.

3. WHAT IS ECODEVELOPMENT?

(Madhav Gadgil)

3.1 Prudent Resource Use

What shall we then do if the economic growth achieved by us over the last three and half decades has only been at the cost of the country's capital of natural resources and if it has failed to alleviate the poverty of our masses? Should we attempt to recreate a pre-industrial agricultural society, or even an idyllic age of hunter gatherers? Apart from the dubiousness of the claim that people enjoyed a better quality of life in these eras, it is evident that we cannot go back to these ages. For India is not the only nation on the earth, and if we give up on technological progress, we will again fall prey to one or the other of the technically advanced nations as we did two centuries ago. So it is essential that we continue our scientific and technological advances. And apart from this practical imperative, science and technology are part of the great human adventure that mankind has been pursuing ever since our ancestors first employed tools and fire on the African Savannas. It is an adventure that we cannot and should not opt out of. But science and technology are by themselves neutral, they could be employed to make good use of the bounties of the planet earth, or to destroy it utterly. The Western civilization that created the modern scientific method and the modern technology has by and large employed it towards wasteful and destructive use of our planetary resources. This is where we must show our Indian genius instead of blindly imitating the West. In conformity with our traditions, we must then develop science and technology towards efficient, prudent, conservative use of the resources of our land to provide a better quality of life for all. Eco-development would be the pattern of development that would flow from such an approach towards resource use.

3.2 The Gains and the Sacrifices

While this approach calls for a high degree of scientific and technical innovation, it would also require proper social motivation. For an efficient use of resources calls for a broad-based co-operative effort that is possible only in a

harmonious society. This would be a society in which both the gains and sacrifices are shared in a just and equitable fashion. Unfortunately, our current wasteful pattern of resource use achieves just the opposite. It ends up thrusting the sacrifices on the poor and the weak, while the benefits are cornered by the rich and the powerful. Consider, for instance, power generation. For hill tracts like the Western Ghats, hydroelectric power generation is an attractive possibility. But over the years we have tended to maltreat and undercompensate the peasants, and worse still the landless whose farms and houses are submerged by the reservoirs of the hydroelectric power projects, while the power so generated has been supplied at highly subsidized rates to power guzzlers such as aluminium industries. Or take chemical industries such as Mavur Rayons, West Coast Paper Mills, Binaga Caustic Soda factory or Zuari Agrochemicals. These have all been permitted for too long to degrade the water and fish resources of the land on which depend the local people with near complete impunity. This has obviously to cease. Let us by all means have technology, industry. But the industry must pay the full social costs of restoring the quality and quantity of the resources they degrade. If paying such a cost is an excessive economic burden on the industry, then, clearly such an industry should not be established or continue to function.

3.3 New Directions

But enough of the don'ts. There is much positive to be done to organize a far more efficient use of the resources in our vast country. The effort has to go on in the cities and towns and in remote villages and tribal hamlets. It is at once a social and a technical problem, neglected because our development agencies as well as the scientific community have been geared to serve the interests of the elite, which unfortunately lie in wasteful use of resources to make quick profits. It is heartening, however, that there are many new initiatives in the right direction, both on part of development agencies and the scientific community, as well as voluntary agencies. Many components of the programmes of social forestry and wasteland

development board, draught prone area programmes, rural landless employment programmes and so on have a focus on the good use of the resources of our countryside to provide a better quality of life for the weaker segments of the rural population. At the same time there is much voluntary effort, following especially the lead of Dasholi Gram Swarajya Sangh of Garhwal Himalayas that is now focussing on ecodevelopment. There is also new effort within the scientific and technical community, such as that by the ASTRA (Cell for Application of Science and Technology to Rural Areas) group of the Indian Institute of Science, Bangalore.

We must here reassert our belief that this endeavour is not simply a matter of halting industrialization. Industrialization has to continue but without being permitted to wastefully destroy resources. It is also not simply a matter of going back to resource use practices of an earlier era. Those practices were grounded in a hierarchical caste society that has broken down and in conditions of a far more favourable resource/people ratio. In the modern era we have to recreate traditions of good resource use which need extensive new scientific and technical inputs as well as new patterns of social management of resources. Besides permitting a sustainable use of resources, this new pattern would also serve the cause of social justice by creating more rural employment and protecting the resources on which the poor depend for many of their basic needs. It is therefore an endeavour very worthy of serious attention by both the scientific, technical community and those engaged in voluntary development effort, be they in the National Service Schemes of Colleges, in farmers' co-operatives, rural youth clubs or ladies clubs, or in active voluntary agencies. It is to these sectors that we address this manual, hoping that it would be of some assistance in this great challenge of ecodevelopment.

4. FOCUS ON WESTERN GHATS
(Madhav Gadgil)

As a focus for this manual, we chose the hill tracts of the Western Ghats stretching from river Tapi in the north to Kanyakumari, at the southern tip of the Peninsula. The spine of the Western Ghats runs parallel to the West coast with many spur hills jutting all the way to the sea. Standing in the path of the monsoon winds, these hills cause the moisture laden air to rise leading to copious precipitation. The rains are however limited to just four months in the northern stretches, gradually extending to eight or nine months as we go south. This precipitation ranging from 2000 to over 8000 mm a year supports a lush forest cover under natural conditions. This forest cover has however been extensively altered, sometimes to be replaced by green paddy fields or plantations such as those of arecanut, tea or rubber. In many other localities it has been stripped away only to give way to a man-made desert of lateritic rocks. This potentially rich, but fragile tract therefore calls out for ecologically sensitive treatment.

4.1 Spice Orchards

We have ourselves been involved in one such effort in the district of Uttara Kannada. This northernmost coastal district of Karnataka lies in the middle of the Western Ghats, in a Zone of transition between the northern basalts and the southern precambrian rocks. The Western Ghats are at their lowest in this district; the crestline ranging around 600 m for the most part. The westward slopes too are moderate, and the coast rather narrow with the spurhills running all the way into the sea. The undulating topography is at its gentlest in the three taluks of Yellapur, Sirsi and Siddapur creating conditions highly favourable for a multistoreyed spice orchard of arecanut, pepper, cardamom and banana in the valleys. The orchards are protected from excessive sunlight by the tree clad hills fringing the valleys. Parts of valleys, especially where they are too broad are put under paddy cultivation with a little sugarcane. This agriculture and horticulture is

supplemented by maintenance of a good number of cattle. The hills provide grazing for the livestock, whose dung is much valued as fertilizer. The hill forests provide dry leaf as mulch for the orchard, green leaf as animal bedding to be converted after use into manure as well as green manure for direct use. And they also provide fuel, usually extracted as branches while cutting for dry leaf mulch.

4.2 Hill Forests

The hill forests therefore play a vital role in the economy of these tracts. They are under six systems of management. About 40% of the district used to be Reserved Forest, though the extent is now somewhat reduced through river valley projects etc. Villagers are permitted to graze in the Reserved Forest, except in new plantations, but have limited access otherwise. Minor forests, also under the control of forest department are areas open to grazing, as well as collection of firewood by the villagers. Hill forest areas known as Soppinabettas (Kannada:- Soppu=leaf, betta = hill) are assigned to arecanut orchard owners in ratios varying from 1 hectare of orchard to 4 to 9 hectares of soppinabettas for meeting their plant biomass requirements, but without a right to cut trees. These soppinabettas may be managed either communally by the orchard owners of a village, or may have been assigned individually. The soppinabetta lands used to be owned by the Revenue Department, but have now been transferred to Forest Department. The minor forest and soppinabetta lands constitute another 40% of the district's land. In addition there are 'Kan' forests or sacred groves, supposed to be left totally unexploited except for removal of dead word and a few forests managed by forest panchayats. Of all these the soppinabetta and minor forests are obviously of great significance in the village economy.

The major community of orchard owners of Uttara Kannada district is known as Havyak Brahmins. They constitute nearly half of the population of the taluks of Yellapur, Sirsi and Siddapur. A second major community, of these taluks, Naiks, are paddy cultivators. Mukhris are a mostly landless scheduled

caste. Substantial amount of labour comes to the upghat taluks from the coast as migrant labour, many of them belonging to the community of Patagar gowdas.

4.3 A Progressive Co-operative

In all of this tract, a part of Sirsi taluk is famous for its productivity and hence called "Totada Seeme" (Kannada: Tota = orchard, Seeme = Outer limit) or the highest expression of orchards. Lying between 74°49'E to 74°51'E and 14°40N to 14°44'N at an altitude of 500 to 600 m, the region receives an annual precipitations of 2500 mm with remarkably little variation from year to year. Totada Seeme is served by one of the best managed co-operative societies of Karnataka, the Hulgol Group of Villages Co-operative Service Society, with its headquarters at Bhairumbe (Taluk Sirsi, Dist. Uttara Kannada 581405). This Society, founded in 1919 has been taking special interest in technical developments in the last decade and half. In 1970's it launched a whole farm demonstration project in collaboration with the University of Agricultural Sciences, Dharwar. Its findings were published as a book in Kannada titled "Agriculture in Malnad" on the occasion of the Society's diamond jubilee in 1979. Implementation of the practices recommended in this book has led to further increase in the productivity of the orchard owners of this region. They are people at the forefront of modernization having introduced biogas plants as much as a quarter of a century ago, a lucrative crop of cocoa to replace bananas falling prey to diseases, and practices such as planting of Glyrecedia, a leguminous shrub along farm bunds to provide green manure.

5. BHAIRUMBE : A CASE STUDY

(B.K.Mishra AND Madhav Gadgil)

5.1 An Island of Prosperity

By any standards, and certainly by those of India, TTotada Seeme harbours of a prosperous community, well able to keep up with the times. Its fertile fields and orchards nestle amongst green hills, whose tree cover is not as yet excessively degraded. But there are problems that have roused the ever alert Hulgol Society into ecodevelopment action over the last four years. The best way to understand the nature of these problems, is to look at the biomass budget of the region. To this end we have attempted a survey of part of the region, the village of Bhairumbe employing a census approach. While the investigation is yet to cover several pertinent aspects, we are in a position to provide a preliminary, albeit somewhat idealized picture. Qualitatively, this is quite accurate, although there may be some quantitative changes as we complete our investigation which will be published along with the technical details. In view of this, we have rounded off some of the numbers for ease of presentation below.

5.2 Social Structure

The 80 households inhabiting this tract fall into two major classes, the landed, of which there are 48 (or 60%) all belonging to the higher castes, and landless, of which there are 32 (or 40%), nearly all belonging to backward and scheduled castes. The average household size is 7.5, with the total population at 600. Of the 600, a quarter are children below thirteen years of age, 5% are over 60 years and the remaining are males and females of the working age, with the sex ratio slightly biased in favour of females because of some outmigration of younger males.

The 48 landed households, between themselves own 35 hectares of paddy fields (gadde land), 40 hectares of arecanut orchards (Tota land), and 20 hectares of hilly land under grass cover (bena lands). In addition, they have

exclusive access to 100 hectares of soppinabetta lands, although these lands are owned by the Government. The 32 landless households have access to 75 hectares of minor forest land to meet their requirements of fuel and fodder. In addition, the landowners too can and do use the minor forest, especially for the supply of green manure and grazing their animals. The livestock are owned largely by the landowners; with 360 out of 400 animals belonging to 48 landowning households. The 32 landless households own 40 animals amongst themselves. The 48 landowners all have houses with tiled roofs, the 32 landless have mostly houses covered with coconut or paddy straw thatching.

5.3 Biomass Production and Use

The primary produce of the paddy fields and the arecanut orchards is of course the grain, and fruit. But these crops also produce straw as well as woody matter which is used as fodder, thatch and fuel. The bena, betta and minor forest lands too produce grass, leaves and woody matter utilized as fodder, manure or mulch. We have attempted an estimate of the production of this matter based on a sample survey. Their annual harvests by man, in tonnes of dry weight per hectare are as follows:

	Gadde (35 ha)	Thota (40 ha)	Betta (100 ha)	Bena (20 ha)	Minor Forest (75 ha)
Fuel	0	1.25	3.4	0	1.6
Fodder	5.7	0	0.8	2.0	0
Mulch and Manure	0	0	1.1	0	5.6
Thatch	0.7	0	0	0	0
Total	6.4	1.25	5.3	2.0	7.2

Per Hectare Annual Harvest of Dry Weight in Tonnes.

It may be noted that bulk of paddy straw is used as fodder along with a certain amount of grass hand harvested from soppinabetta and bena lands, usually in late October-November.

The grass harvested by animals themselves through grazing may be substantial, especially in the minor forest area. This has however not been included here. The areca leaves from the orchards provide considerable amount of fuel as do the sticks from loppings from the Soppinabetta lands. The trees are loppend after monsoon and the loppings allowed to dry, with the dry leaf used as mulch. Green leaf, used as animal bedding and subsequently converted into manure is largely removed from the minor forest land.

Given these per hectare productivities, the total production of these biomass components from these land categories is as follows:

	Gadde	Tota	Betta	Bena	Minor Forest	Total
Fuel	0	50	340	0	120	510
Fodder	200	0	80	40	0	320
Mulch and Mannure	0	0	110	0	425	535
Thatch	24	0	0	0	0	24

Total Annual Harvest in Dry Weight in Tonnes

To the mulch and manure derived from plant material must be added the dung of 400 animals all of which goes into manure, none being diverted to fuel in this region. We estimate 112 tonnes of dry weight of such dung, namely 0.35 that of the fodder supplied in the stalls to be so available. Thus 647 tonnes of dry weight of organic matter goes back to 35 hectares of paddy fields and 40 hectares of orchards.

5.4 Problems of Distribution

The overall availability of biomass thus appears quite adequate. The fuel works out at 0.85 tonnes per person per year, well above the national average of 0.5 tonnes; or the stat average of 0.35 tonnes. The consumption is somewhat higher in the tree clad district of Uttara Kannada; the average being 0.67 tonnes. But even this is below 0.85 tonnes. The fodder availability comes to 0.8 tonnes per year per cattle head.

Given the small size of many local cows this level of feeding is not too poor either, although the average milk production by lactating animals is only 1.14 liters per day. The availability of organic manure comes to over 8.8 tonnes per hectare of cultivated land; which again compares favourably with the general prevalent situation, although still inadequate to fully restore soil nutrient stock.

But in the midst of this aggregate picture, we must not lose sight-of the fact that the resources are not equitably accessible to the whole population. This may be best brought out by contrasting the position of 48 landowming and the 24 landless households. Of the 510 tonnes of fuel, 390 tonnes go to the landed and 120 to the landless. This means a per capita annual consumption of 1.08 tonnes by the landowners and 0.5 tonnes by the landless. The high level of fuel consumption of the landowners, especially to heat bath water was publicly remarked upon by Dr. K. Shivaram Karanth, the noted Kannada intellectual, in his valedictory address to the seminar on the environmental impact of Bedthi hydroelectric project in January 1981. In his words, the orchard owners daily burn enough fuel to serve for cremation of five corpses in other parts of the country!

The 320 tonnes of fodder too is all available for the 360 animals owned by the landowners. The 40 animals of the landless must either graze on public land or be fed on purchased fodder which the owners cannot easily afford. It is also these 24 households who largely live in thatched huts which must get a fresh covering of paddy straw or coconut leaves every year. This too they have to purchase. Thus, in spite of the apparently satisfactory state of affairs revealed by the aggregate picture, there are serious resource constraints experienced by a sizeable segment of the population.

5.5 Managing the Resource Base

Is the resource base of Bhairumbe village being sustainably utilized? The main resource for lands under active cultivation is the soil and its nutrients and the surface and ground water. We do not immediately have adequate information to be sure of

what is happening to these resources. However, it may be mentioned that the intensification of cultivation has been accompanied by serious problems of diseases and pests in the last decade. A second crop of paddy was taken up some years ago, but was abandoned due to the high levels of insect pest attack. From the orchard too pepper, of which there used to be one vine for every areca tree has been totally wiped out. Banana and cardamom have also suffered much, leaving areca and newly introduced cocoa the two main props of the horticulturist.

What then of the bena? Its yearly grass harvest of 2 tonnes per hectare, followed by routine fire in the summer may not excessively deplete the soil. But the coarse grass harvested after seeding is very poor in nutrients and its production is not a very good land use. Our estimates of annual removal of organic matter from the soppinabetta and minor forest lands come to 5.3 and 7.2 tonnes per hectare. To this must be added matter removed by grazing, perhaps another 2 to 2.5 tonnes per hectare. This implies a total removal of 7-10 tonnes per hectare per year. Given the annual precipitation of 2500 mm, this moist deciduous forest should have an above ground annual production of 12-15 tonnes per hectare, so that the removals may be sustainable under good management. However, both the Soppinabetta and Minor Forest lands are currently rather degraded and estimates based on our litter production studies suggest that their current annual productivity levels may be of the order of 6.5 tonnes of above ground biomass per hectare. The present levels of harvest are then excessive.

The present levels of harvest are also excessive because of the manner of harvest. The harvesters, primarily the landless employed as labourers by the landowners have no personal stake in the long term sustainability of the resource base. They therefore tend to maximize the amount of plant matter collected per unit time spent in harvesting. The result is that no leafy matter, not even the apical shoots are spared so that the photosynthetic and growing abilities of the plants are drastically reduced. The result has been a progressive

deterioration of the plant cover of both soppinabetta and minor forest lands.

The same applies to grazing by cattle. The acutest problem is for the cattle of landless in the dry season when the grass has dried up. In absence of any regulation, all accessible areas are uniformly and heavily grazed. The fires that are then set in early summer in the hope of getting fresh grass growth with premonsoon showers further affect the vegetation adversely.

Thus there are serious problems of sustainable management of resources even in this island of relatively well maintained vegetation on the Western Ghats. The progressive and well organized farmers of the region, becoming aware of these constraints soon after the completion of the whole farm project in the late 1970's have taken several innovative steps to improve the management of the biomass resources of their tract.

6. WORKING WITH PEOPLE

(Madhav Gadgil and K.M. Hegde)

6.1 The Background

This crisis of biomass did not, of course, surface all of a sudden. It had been building up over the years with the increase in the population consequent on the eradication of malaria by 1950, and the mounting pressure of forest based industry, which for instance, had wiped out the rich bamboo stocks of the district by 1960's. The mounting biomass crisis was accompanied by opening up of new opportunities as electric power reached the region in 1960's greatly enhancing possibilities of irrigation, as chemical fertilizers became available and as improvement in communication suggested new marketing opportunities as for the milk. Totada Seeme farmers responded to these changes in many ways. As the depletion of Soppinabetta lands became clearer, some deliberately reduced the lopping pressure confining themselves to collection of dry and fallen leaves; while others further stepped up lopping. A number of farmers began dairying attempts in early 1970's purchasing high yieloing Jersey and other cows. But such animals had to be totally stall fed on purchased concentrates and fodder. This was not really practicable, especially with the local milk marketing co-operative going bankrupt. The farmers then saw that if they were to produce milk for market, it must be based largely on fodder production on their own lands.

By 1980, the farmers had clearly realized the need for far better management of biomass and of positive attempts to enhance biomass production. This was given an impetus by the discussions at a three day conference on the "Effect of Hydroelectric Projects in Uttara Kannada district" held at Sirsi in January 1981. This brought the orchard owners in close touch with a number of scientific and technical people as well as Government officials. These draw attention to the apparently wasteful and poor management of their natural resources by the orchard owners who were stimulated to make some serious positive effort. At the same time the Governments

had begun to think of these problems, leading to the establishment of Departments of Environment at the Centre as well as in the Karnataka State. The scientists were also following suit and there was new emphasis on Agro-forestry in the University of Agricultural Sciences, Dharwad and on ecology at the Indian Institute of Science, Bangalore. All of this led to the initiation of an experimental project on ecodevelopment through the Hulgol Group Villages Co-operative Service Society as a collaborative attempt of the farmer members of the co-operative, Government department of Ecology and Environment, Forest, Animal Husbandry and Veterinary Services and technical institutions such as the Indian Institute of Science and the University of Agricultural Sciences and other voluntary development agencies such as the Bharatiya Agro-Industries Foundation. The project was launched in March 1982, with the Karnataka Government providing for technical support through a small grant of Rs. 74,000/- over a three year period.

6.2 The Project

The objectives of the project were defined as :

a) To introduce better practices of harvesting trees on soppinabetta lands for leaf manure, mulch and fuelwood, so that the productivity of the tree crop of these lands will be sustained.

b) To stock the soppinabetta lands with a variety of useful tree species to augment their presently depleted tree cover coupled with protection against fire and grazing with the development of live fences such as Agave.

c) To upgrade the genetic quality of livestock coupled with the introduction of rotational grazing and stall feeding.

d) To develop the fodder resources by introducing better varieties of grass, ground covering legumes and other fodder crops and fodder trees such as subabal on bena and soppinabetta lands and the cultivation of crops such as cow-pea as a second crop on paddy lands.

e) To improve the efficiency of the use of leaf manure, mulch and fuel by introducing practices such as the use of dead and

fallen leaves instead of green leaves, more efficient wood stoves for cooking, heating water, manufacture of jaggery, boiling arecanuts and developing the technology of biogas based on weeds like Eupatorium.

The project was organized as a field test of these various concepts and technologies by 15 volunteer farmers. The farmers were not to receive any financial subsidies, rather they had to invest on their own for many of the components. This insistence ensured that the experiment would be taken up by only those genuinely interested; it however limited the participation to those with minimal financial resources. Of these 15, 12 farmers belonged to the Hulgol cluster of villages; 3 others were from the neighbouring areas in Yellapur and Siddapur taluks. Their landholdings ranged from 0.4 to 2.2 ha of orchard, 0 to 2 ha of paddy, 0 to 4.8 ha of bena and 2.4 to 16 ha of bettalands, with 7 to 26 cattle heads.

6.3 Soppinabetta Management

Traditionally the Soppinabetta trees were lopped once every three years, and much greater care was taken when the orchard owner's own family used to undertake the lopping. Recent years have witnessed the beginning of lopping of each tree every other year, with little care as labourers began to be engaged to discharge this task. Consequently the tree crop has started dying out, leading to further intensification of lopping pressure. The farmers volunteering in this programme have all given up lopping altogether, restricting themselves to the collection of dead and fallen leaves. This is supplemented by green leafy matter from trees such as Glyrecedia grown on farm bunds. The need for mulching material is being reduced by growing cover crops such as Mimosa invisa and Pueraria javanica on the ground inside the orchards. Dry grass is also being used to supplement mulching material.

In addition, specific trials have been conducted to evolve alternative systems of lopping every five years, with the top one third of the tree being left intact at all loppings.

Planting has been taken up in the soppinabetta lands of all 15 participating farmers. The land planted at the density of 2mx2m, without harming natural growth, comes to 43 acres 11 guntas (17.53 ha). The land has been protected with the help of a trench dug all around, and planted on the soil mound formed inside with species such as Agave, bamboo, Casuarina and Duranta. The pits are 30 cmx30cmx30cm in dimension and were most advantageously dug immediately after the previous monsoon. A total of 52,763 plants belonging to 36 species have been planted, apart from the hedge plants. Their overall survival computed for the first two years has been 73.9% but the greater mortalities were primarily in the first year because of the use of naked seedlings and some uncontrolled fire. The lowest survival over the first two years was 31.6% in a very degraded site; and the best was 92.6%. In the third year i.e. 1984-85 the survivals are expected to have reached over 80% for all farmers.

The species tried included both indigenous and exotic species. A local species, Nandi (Lagerstroemia lanceolata) had the best overall survival of more than 80%, though its growth is moderate. Other local species with survival over 60% include Nerale or Jamun (Syzygium cumini), Kaidhupa (Vateria indica), Honge (Pongamia glabra), Shivani (Gmelina arborea), Kadamba (Anthocephalus cadamba), Kalgangi (Chukrasia tabularis), Gulmavu (Machilus macrantha) and Balanji (Acrocarpus fraxinfolius). Of the exotics Acacia auriculiformis, Swietenia mohogani and Cassia siamaea had over 60% survival. Acacia auriculiformes had particularly rapid growth. Of the native species Matti (Terminalia tomentosa) and Hebbalasu (Artocarpus hirsuta) had very poor survival, below 20%. Of the exotics subabul Leucaena leucocephala did very poorly on bettas because of extensive browsing by wild animals, although it grew well under protection. Nelli Phyllanthus emblica, bamboos and Casuarina did moderately well.

The farmers maintained careful records of their inputs. These show that digging a good pit and a trench were their major expenses, coming to 50 paise per seedling on each head. Labour for planting cost 17 paise and weeding and soil work another

17 paise per seedling. Thus each farmer has invested Rs. 1=35 per seedling; or a total of Rs. 65,000.00 in the soppinabetta planting component of the project. It costs an average of 40 paise to raise a seedling in a polythene bag, with transport taking up another 10 paise per seedling. This brings us to an investment of Rs. 4,625.00 per hectare if planting is at a spacing of 2m x 2m. If the seedlings are raised in dispersed nurseries close to the planting site, this would save Rs.250.00 out of this cost. Even more significantly, if everybody takes to stall feeding and no trench is needed, the per hectare cost could come down to Rs. 3,135.00. Experiments should also be tried of some investment in a few irrigations in dry season, in water conservation measures and in fertilizing. The additional growth put on may fully justify such investment.

However, if the farmer is to invest he must have an assurance of a return on his investment. Unfortunately, the Government attitude had till recently been one of moving in the direction of claiming all rights over trees everywhere, especially on Government land. Fortunately, a fresh breeze is blowing and we are moving in the direction of conferring greater and greater share in the tree produce to the individual farmer, or landless labourer. Such "tree pattas" are bound to create a stake in the welfare of the trees on part of the people looking after it.

6.4 Peoples' Nurseries

Availability of good quality seedlings close to the planting site is vital to the success of any revegetation effort, not only as it would cut transport costs, but also because it would encourage the planting operation at the correct time. With the massive planting efforts on horizon, this calls for decentralized small nurseries. Since labour is a major component of nursery work this provides an ideal employment generation opportunity. Soon after planting in the season of 1982 and 1983 the farmers felt the need of such nurseries, which seemed possible through the social forestry programmes then being launched. A 5 day training programme was therefore organized in October 1983 at the Vidyodaya Junior College at

yadahalli, a village in Sirsi taluk to train prospective nursery raisers. This was followed by two nurseries, one at the Vidyodaya Junior College at Yadahalli and another at the high school at Bhairumbe raising 10,000 seedlings each for planting in the monsoon of 1984. Three other nurseries were similarly raised with the initiative of the forest department at Unchagi, Masur and Muroor in Kumta taluk . This first year's experience was needed to sort out initial problems and for people to feel reassured of payment for the effort and money put in. In 1984-85 season, the effort has taken true mass proportions in the Sirsi Division, thanks to the enthusiasm of the local Deputy Conservator of Forests. There are now 38 "People's nurseries" raising a total of more than 16 lakh seedlings. These include the Vidyodaya Junior College at Yadahalli which has raised 30,000 and the High School at Bhairumbe, which has raised 20,000 seedlings besides the Yuvak Mandali at Bhairumbe raising 50,000 seedlings, and the Yuvak Mandali at Hulgol raising 1000 seedlings. A number of private farmers are raising most of the remaining seedlings.

6.5 Animal Husbandry and Fodder

With the traditional abundance of grazing on bena, soppina-betta and minor forest lands, the farmers of the tract are used to maintaining large herds of livestock. The livestock holdings of the 15 participating farmers in this project ranged from 6 to 40 with a median of 12. Traditionally, these animals produced small quantities of milk for home consumption and a good amount of dung for manuring the fields and orchards. Dairying, namely raising cattle for milk yield is therefore a new concept, as is the scarcity of fodder for animals and their adverse effect on vegetation, especially the regeneration of tree growth that is now of vital concern. This transformation of animal husbandry proctices needs an emphasis on fodder production and cattle management with genetic upgrading. The Department of Animal Husbandry, traditionally devoted to curing diseases is only now beginning to awaken to the needs of this approach.

The participating farmers in this project have uniformly succeeded in switching over to the modern approach over the project period. All of them now stall feed the cattle throughout the dry season when the damage to tree regeneration would be maximal. They have succeeded in cross breeding their animals, thanks to the frozen semen facility extended to the Hulgol co-operative Society by the University of Agricultural Sciences.

The development of fodder has picked up well. The greatest success has been growing sunhemp as a fodder-cum-green manure crop on residual moisture after the Kharif paddy. This has surpassed the performance of fodder cow pea grown in 1982-83 in a similar fashion. There has been only limited success in growing a fodder yielding cover crop in the orchards, but subabul (Leucena leucocephala) has done very well on the boundaries of orchards. However, subabul did poorly away from the protection near the orchards and houses. Another leguminous medium sized tree, Calliandra Callothyrsus was introduced on a limited scale in 1984 through the courtesy of Conservator of Forests, Kanara Circle and appears to be doing even better than Subabul. Several grass species; Napier, NB-21, Co-1 and climbers like Centrocema have done quite well in open spaces in the orchards where there was some irrigation. There has however been no success in finding a suitable grass or legume to grow on soppinabetta and bena lands under rainfed conditions, although several species such as Sudan grass, Setaria; Dolichos highworth are being tested.

The outstanding success has been rabi sunhemp crop, whereby hangs a tale. The demand for its seeds has shot up from 4 kg in 1983 to 5500 kg in 1985 from the Hulgol Society members. The Society has procured the seeds from private dealers. Now the Department of Agriculture of Karnataka State has a programme to grow sunhemp as a green manure in March-April and supplies seed for this purpose. Our farmers sow it in December-January, get two cuttings for fodder and then plough it in as a green manure in April. But the Department of Agriculture holds this behaviour against rules and has refused to supply seeds in spite of a number of attempts!

6.6 Fuel Conservation

The per capita demand for fuelwood for Uttara Kannada district is twice the state average. Forty years ago Uttara Kannada was still a malaria infested tract that had been steadily losing population since the census of 1901. People believed forests to be the root cause of malaria and were clamouring for deforestation. Highly wasteful use of fuel might therefore have been their way of correcting the situation, a tradition which now has to change.

This is very evident on the coast, though not as much at the "Hotada Seeme". However, even here fuel economy is now being apreciated. The right answer is provided by a number of deviced developed by the Engineers and Scientists of the Indian Institute of Science, especially its ASTRA group. These devices range from cooking stove, stove for heating bath water, stove for making jaggery to a stove suitable for a hotel, currently under development. They can be fabricated locally by trained local people, using local materials except for iron grates and asbestos pipes. The improvement in the efficiency of fuel use is substantial. Farmers from the Hulgol Society have taken a lead in constructing these stoves in their homes, at their own cost and over 200 of the society members now have Astraole, the improved cooking stove. A substantial number also have the bathing water stove which can be heated solely on areca husk that had little use earlier. Finally, there are already 5 jaggery making stoves which can run on bagasse alone, while the traditional stove uses large quantities of logs.

6.7 Wider Diffusion

The improved practices introduced in the project have diffused well on their own. Thus in one of the hamlets of Bhairumbe there are 13 landowners and 19 landless families. One of the 13 landowners was a volunteer farmer for the project. A survey of these 32 families in 1985, three years after the commencement of the project has been most revealing. The cooking stove is common to every hearth and home. Today 4 of

the landed families have biogas plants and 6 have Astraolcs, leaving only 3 with traditional chulas. 3 of 19 landless have astraole: many others have made preparations to build one;the 4 scheduled caste families have applied for free construction for which they are eligible, while 2 others are waiting for subsidy. All households also heat bath water; 4 of the landowners and 2 of the landless have constructed the fuel efficient versions. Three of the landowners have also constructed fuel efficient jaggery stoves.

Eight of 13 landowners have stopped lopping their soppinabetta; two other have moderated the lopping. Three of them have effectively stopped grazing in their soppinabetta lands, though there has been little investment in planting other than by the project volunteer. There has, however, been considerable interest in fodder development and 9 landowners have planted subabul and 10 of them grow sunhemp or fodder legumes.

The number of local cattle, maintained by the landowners has gone down from 112 in 1982 to 25 in 1985; while the number of cross breds has gone up from 13 in 1982 to 62 in 1985. There is thus a net decrease in the total number of cattle owned by the landowners from 125 to 87. On the other hand the landless had 27 local and no crossbred cattle in 1982; today they own 23 local and 6 cross bred cattle; thus having marginally increased their cattle holdings. All the cross bred animals, including those owned by the landless are stallfed outside of the rainy season. However, while the landowners stall feed their local cattle also in the dry season; the local cattle maintained by the landless are free grazing throughout the year.

These free grazing cattle come into conflict with those who have trenched and closed their soppinabettas to grazing. Protected as they are, these soppinabettas become the most attractive grazing grounds at the height of the summer when all else has been grazed out. There have been deliberate attempts to then break into these lands leading to conflicts. In fact a local newspaper in Sirsi picked up this controversy and dubbed one of the project volunteers "gohantaka" - slayer of the cattle!

6.8 Tackling the Commons

It is evident that serious thought needs to be given to resolve the problem of fodder supply for the cattle of the landless. The lands traditionally meant for their grazing are the minor forest lands. Managing these lands better is a matter of communal agreement, with one dissenting voice being enough to render the whole programme null and void. There were of course older communal traditions which successfully dealt with the problem; these have, however, largely disappeared. The need of the hour is then to recreate them in the modern context.

Such an attempt was begun with the minor forest of Bhairumbe, with a portion trenched and planted with the help of the forest department. As might be expected, there were problems, not with residents of Bhairumbe who agreed to co-operate, but with those of a neighbouring village. However, even this problem has been surmounted in 1985. As the original project is closing in 1985, the new initiative of tackling the problem of good management of common lands is beginning to bear fruit !

In fact, as the Hulgol Society's report concludes on an optimistic note, what was started as an experiment in 1982 has struck roots in the District with ecodevelopment being considered as a vital supplement to the normal developmental activities; if not as yet as an alternate path to development!

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7. WATER

[Madhav Gadgil]

7.1 A vital resource:

Water is by far the most abundant molecule in the bodies of living organisms, and essential for all their activities. Supply of water in proper quantities is therefore a key element in good management of biological production. The Western Ghats tracts are fortunately blessed with copious rains, albeit restricted to 4 to 8 months of the year. This precipitation supported a lush cover of forest under natural conditions, it has been replaced by equally lush plantations and paddy fields in a number of cases. Unfortunately, in other cases it has been replaced by a man-made desert of hard laterite pans which do not allow of proper percolation of rain water to the underground aquifers. The rain water flows through streams, rivulets and rivers to either side of the Western Ghats. The short west flowing rivers are ephemeral, often drying up after the monsoons. This water has traditionally been trained, channelled for irrigation through small bunds, and canals meandering across the hills. Where the rivers join the sea are wide estuaries, earlier flanked by mangrove swamps. These lands have been converted to paddy and coconut fields almost everywhere. The underground water has been tapped by wells, which used to serve for drinking

water and to irrigate small plots in days when water was drawn by hand.

Now there are huge dams, for both hydroelectric power generation and for irrigation as many rivers of the Western Ghats. These have considerably altered the pattern of flow of water in the river courses. The electric power generated has permitted much more intensive tapping of underground water, permitting an intensification of agricultural production. This has sometimes led to a rapid lowering of the underground water table.

The waters have also been affected by the increased discharge of sewerage, and much more seriously by the discharge of effluents of chemical industry such as paper, rayon and fertilizer factories.

Traditionally there was a certain emphasis on coupling efficiency to intensification of resource use. The former has been largely overlooked in recent decades. The need now is therefore for a much more careful and efficient use of the bountiful water resources of the Western Ghats.

7.2 Sources, end uses and control

In order to plan for such use calls for careful considerations of three dimensions; namely the sources of water, the end uses of water and the social mode of

control of the various elements of water resources.

The sources may be broadly classified as:

(a) Rain

(b) Running fresh water on surface in seasonal or perennial streams, rivulets and rivers

(c) Brackish water in estuaries

(d) Sea water

(e) Fresh water impounded in small check dams, farm ponds, larger irrigation ponds, major reservoirs

(f) Underground water.

The end uses may be classified as:

(a) Domestic-drinking and cooking

(b) Bathing

(c) Drinking and bathing of domestic animals

(d) Irrigation for cereal crops, horticultural crops, other tree crops

(e) Production of aquatic animals, shellfish, prawns, crabs and fish

(f) Generation of power, mini-, micro- and macro-hydroelectric power production

(g) Disposal of domestic wastes

(h) Disposal of industrial wastes.

The patterns of control over water resources may be classified as:

(a) Individual land owner

(b) Communal organization such as temples

(c) State organization such as Public works Department, Irrigadion Department or Forest Department.

7.3 Action points

We have to plan for efficient use of water resources taking all these factors into consideration. The major action points that emerge include:

(i) Organizing prevention of soil erosion coupled to efficient percolation of rain water to recharge underground aquifers. The measures, will have to be suited to the conditions of slope and soil structure and prevalent pattern of land use, for instance, whether the land is under hill agriculture, under tree crops etc. The measures to check soil erosion and to promote percolation of water apart from revegetation which will be taken up later, may include small saucers, bunds, terraces, gully plugging and check dams.

(ii) Organizing small scale storage of water for irrigation purposes to get over the difficulties of water supply in the dry season. Such storage may be in the form of small scale bunds on streams, farm ponds taking advantage of the natural topography of the cultivated land, etc. A novel idea suitable for the lateritic rock tract of Western Ghats is a proposal by Dr. Athavale of ICRISAT to cut the rock in the form of a cubical tank to be lined to prevent percolation and based on the

natural catchment with its heavy rainfall. This is currently being experimented with near Malavan in Sindhudurg district of Maharashtra.

(iii) There is very considerable scope for greatly increasing the efficiency of use of water in irrigation. There is also a need for experimenting with possibilities of providing minimal irrigation for tree, grass and legume crops grown on gochar lands, minor forest lands and other hilly lands. The current practices of flow irrigation are highly inefficient and slowly need to be replaced by sprinkler and drip irrigation. The latter are however rather expensive, and alternative simpler and cheaper methods need to be devised. One suggestion is the use of a polythene tube buried so as to take water directly to the root zone of a tree.

(iv) We not only need to take adequate amount of water to the plants, excess water must be effectively drained off. Failure to provide for proper drainage, has, for instance, led to serious problems of water logging and salination in black cotton soils of Maharashtra, Karnataka and Madhya Pradesh. The problems, although less severe in the Western Ghats tracts, nevertheless exist and must be tackled.

(v) The brackish water of estuaries represents an important resource which calls for careful management.

These lands constitute the so-called khar or Gajani lands which can produce a good crop of a special variety of paddy in the monsoon and large catches of prawns in the dry season. But this calls for proper regulation of water flow with bunds and sluice gates. In Kerala too there are extensive backwaters and it is well known that an attempt at management of Wembanad lake has ended in a disaster due to insufficient thought being given to environmental considerations.

(vi) The water resources are also important in production of valuable plant and animal resources in the water bodies themselves. Plants like Pandanus growing along the streams provide material for mat weaving, and shellfish, crabs and fish are important part of the life support system of people living in the area. Little thought has been devoted to preservation of these resources while planning water and land use. This is essential to think about. We must also think of augmenting these resources further by taking advantage of water impoundments of various sizes formed for irrigation and other purposes.

(vii) Water resources of Western Ghats have been tapped on an extensive scale for large scale centralized hydroelectric power generation. There is however a case for considering smaller scale, micro- and mini-

hydroelectric power potential as a desirable alternative, since it could substantially reduce submersion of land and still generate power very usefully for local usage. The potential for such power needs to be surveyed and small scale experiments taken up for its utilization.

(viii) Water for drinking, cooking and bathing for people is a vital resource which needs to be made available. On a proper year round basis and in clean, germ free form. There is much distress on this score in summer in many Western Ghats tracts in spite of abundant rains during monsoon. Proper recharging of ground water and protecting these water sources should be an important component of ecodevelopment activities.

(ix) Not only humans but domesticated animals too need water. Providing adequate clean water for animals should also be looked into.

(x) Finally, the disposal of domestic wastes. Proper sanitation, coupled with conversion of human excreta into manure is very relevant. Devices such as the Sulabha Shouchalaya seem to be very promising in this context.

7.4 The action programme will involve interacting with many different individuals, bodies such as Panchayats or temples and Government departments. We will come to the issues involved in the Sixteenth chapter.

8. LAND

[Madhav Gadgil]

8.1 Land capability and land use

Along with water, land is the other basic resource supporting all biological production. The upper crust of soil covering most land surfaces is largely a creation of living organisms - plants with their roots in the soil and litter dropping on its surface, and the myriads of animals and microorganisms subsisting upon this organic matter. The build up of this soil is a very slow process, taking tens of thousands of years. Proper use of this resource is therefore critical to sustained biological production.

This soil is susceptible to physical removal by wind and water, the process of erosion; it is also susceptible to impoverishment through removal of nutrients that are not replaced. It is necessary to guard against both these dangers. To do so implies that land must be put to uses which are compatible with its capability, and should be treated to promote build up of the top-soil and its nutrient reserves.

The capability of land to sustain different kinds of uses depends on a variety of parameters, the most important being the slope and the depth of soil. By and large, the greater the slope, the less should be

the mechanical disturbance to which it is subjected. Since ploughing is a major mechanical disturbance hill agriculture should be restricted to flat terrain. A whole land capability classification has been built up to provide guidance for land use and an important component of any ecodevelopment programme should be an assessment of land use in relation to land capability. In very many instances, the use would be found to be inappropriate, leading to excessive soil erosion or depletion of its nutrient reserves. A major thrust of ecodevelopment should be on correcting such a situation.

8.2 Reorienting land use

(i) Annual cultivation should be totally restricted to valley and plain lands in moderate and good rainfall tracts. Consequently, alternatives must be found to provide subsistence to the farmers who are cultivating lands unfit for such a purpose.

(ii) Shifting cultivation of hill slopes was feasible when the cycle length was long, it is now excessively shortened, and this system has therefore lost its viability. Under the circumstances, ways must be found of engaging the shifting cultivators in an alternate form of land use which would provide them subsistence.

(iii) A substantial extent of land is devoted to

grazing by animals. This pressure of grazing has now grown to excessive levels, as will be discussed in Chapter 11, all attempts should be made to moderate this pressure on land.

(iv) In agriculture and horticulture there are a number of cultural practices, such as ploughing along instead of across hill slopes which promote erosion of soil. All cultural practices should be assessed in relation to their impact on soil erosion and reoriented to preventing it.

(v) In horticulture and tree cropping cover crops to protect soil against erosion should be developed and encouraged.

8.3 Protecting Soil Fertility

There is mounting evidence now of progressive depletion of soil nutrients under intensive cultivation. This has to be combated by adding micro-nutrients to the required extent, partly through synthetic fertilizers and partly through organic manure. The latter is also vital in improving characteristics of the soil in many ways other than replenishing specific nutrients.

Good management and augmenting the supply of organic manure should therefore play a vital role in ecodevelopment effort. The major sources of organic

manure are:

(i) Leaves from tree growth on minor forest, Soppina-betta and other such forested lands. In certain areas e.g. Konkani such foliage is dried and burnt as raab. This may serve to reduce weed and pest problems in addition to returning minerals to the soil. The use of such foliage has to be looked into and methods of harvesting and using the foliage rationalized.

(ii) Leaves from trees such as Glyrecedia grown on farm bunds and around houses. Such practices should be further encouraged.

(iii) Green manure from special crops such as sun hemp grown in the dry season. Such cultivation could be fruitfully combined with fodder cultivation.

(iv) Animal dung - Livestock has often been maintained as much for its dung production as for providing motive power and milk. Apart from properly managing their grazing, we should also introduce good management of dung. Biogas plants are part of the answer. But we must also consider efficient production of manure in absence of biogas plants.

(v) Proper methods of production of manure employing plant material as well as dung should be propogated.

8.4 Organizing Good Land Use

Today our land is owned by a vast number of peasants in small fragmented holdings, and by revenue and forest departments. There are serious problems of generating good co-operation of people in managing the land held by the Government; and difficulties of implementing anything but annual cropping on part of the vast majority of small holders.

We therefore have to work towards two major objectives:

(a) Finding ways and means of generating co-operation amongst all of the local population and Government bureacracy in proper management of use of land controlled by Government.

(b) Finding ways and means of ensuring good land use on private holdings of peasants.

8.5 Microcatchments as Units

Such an effort at promoting good land use should proceed on the basis of plans prepared for individual microcatchments as units for planning.

9. VEGETATION

[Madhav Gadgil]

9.1 Plant Biomass

The plant biomass still remains the one vital resource directly fulfilling the whole range of basic needs of food, fuel, fodder, fertilizer and structural material for construction of shelters for the bulk of our rural population. Good management of plant biomass from cultivated as well as non-cultivated land must therefore be the key element of all ecodevelopment effort.

Plant biomass may be considered from the three viewpoints of source, end use and social control. In terms of sources the biomass comes from:

(a) Cereal crops
(b) Legume crops
(c) Other annual crops
(d) Horticultural crops
(e) Green amanure crops
(f) Fodder crops
(g) Cover crops
(h) Grass cover of uncultivated land
(i) Tree crops
(j) Shrub and tree growth on uncultivated land

The end uses towards which this plant biomass is put include:

(a) Food production for subsistence

(b) Commercial production for market

(c) Fuel

(d) Fodder

(e) Green manure

(f) Mulching material

(g) Thatching for huts

(h) Poles for huts, fences, small bunds

(i) Bamboos, palm leaves, pandanus leaves for matting

(j) Wood for agricultural implements, doors, windows, beams, furniture, boats

(k) Nectar and pollen for honeybees.

The plant biomass can be owned privately, produced on land owned by institutions such as temples, produced on land held by Government but assigned to an individual for enjoyment of usufruct, produced on land held by Government but assigned to the community for enjoyment of certain usufruct such as grazing by animals, dead or fallen wood etc.

9.2 Action programmes

This biomass has to be well managed and its production from each category of land (by physical attributes as well as social control of land) enhanced in a sustainable fashion.

We may mention here a few of the more important

action points at the risk of some repitition.

(i) Establishment of nurseries in a decentralized fashion through landless and marginal peasants, youth clubs, schools and colleges. These nurseries should not only produce tree seedlings but propagules of grasses and fodder legumes as well.

(ii) Production of green manure and fodder legume crops in fallow season on agricultural fields.

(iii) Production of green manure, fodder, fuel and pole on bunds of fields and orchards.

(iv) Production of green manure, and fodder as cover crops in orchards

(v) Production of fuel, fodder and green manure on privately held hill lands such as soppinabetta and bena lands.

(vi) Production of fuel, fodder and green manure on gochar and minor forest lands.

(vii) Conversion of hill slopes under cultivation to production of fodder and tree crops

(viii) Developing tree crops on degraded revenue and reserve forest lands as social security plantations for landless and marginal peasants.

(ix) Developing nectar sources on fields, in orchards, on private hill lands, gochar and minor forests and in reserve forests.

(x) Socially organizing proper care and sparing of produce from gochar, minor forest and other such lands with communal access.

(xi) Developing bamboos, agaves, pandanus and other plant material as support for rural artisans.

(xii) Developing plant resources in special situations such as river banks, margins of reservoirs, estuaries, land despoiled by mining etc.

(xiii) Developing school forests with fruit and other tree species

(xiv) Developing temple forests.

The next chapter goes into detail with respect to a number of these points.

10. ENHANCING PLANT RESOURCES

[Prabhakar R. Bhat]

A major component of the ecodevelopment effort has obviously to be an attempt at enhancing the plant resources, especially of the marginal lands unfit for intensive cultivation, as well in during the seasons that crop land is best left fallowed. Such an effort requires attention to many components: collection of seeds or other propagules, production of seedlings and other planting material under special care in nurseries, planting out in the field followed by after-care.

10.1 The Seed Material

Seeds collection : The genetic constitution and the environment in which the plants grows affect the growth of plants. To raise high quality plantations, well-filled healthy seeds are required.

Cost of seeds is a minute proportion of the total expenditure for establishing a plantation and is commonly less than 0.1 percent of the total cost, thus the use of seeds from a good source is a good investment for the future.

Seed sources : The genetic quality of a seed is dependent upon both the mother plants and the source of the pollen. Seeds normally should be taken from the very best stands in the region.

Harvesting and processing seeds : Seeds are collected when they are matured. If the fruit is not ripened or the seeds are harvested when the embryo is not sufficiently developed, the seed is apt to be thin, light in weight, shrivelled, poor in quality and short lived. If the harvesting of seeds is delayed too long, the fruit may dehisce or shatter and drop to the ground or be eaten by animals, thus seeds have to be collected at an appropriate time.

Fruit ripening may follow the pattern as mentioned below:-

1. It includes dry fruits that dehisce or open at maturity and distribute single, dry seeds.

Examples : Alstonia scholaris, Albizia sp., Banhinia sp., Xylia xylocarpa, Chickrassice tabularis, Lagerstraemia sp., Glyricidia, Selested, Pterospermum sp., etc.

To avoid seed losses, such plants must be harvested before the fruits are fully ripe and cured before the seeds are extracted. The main problem with this type of seeds is that those may not develop uniformly. A portion of the seed will be immature.

2. It includes the fruits that don't dehisce and do not disseminate their seeds immediately upon maturity. In many cases the nearly dry seeds are collected directly from the mature standing plants.

Example - Terminalia spp., Pteroearpus sp., Dalbergia sp. Pongania sp., etc.

3. The third type includes seeds produced in fleshy fruits. Fully ripened fruits are removed for the seeds - Example : Artocarpus spp., Mimusops sp., Syzygium cumini, Gmelina arborea, Dysoxylum, etc.

Both dry and fleshy fruits can be collected from standing trees, and some seeds can be swept from the fround.

Extraction from pads, capsules may be accomplished by beating the pods. Seeds may require additional cleaning Fleshy parts of fruits must be removed to prevent spoilage and injury to the seeds and the seeds are cleaned and dried.

Seed storage : The collection should as far as possible, be made during dry weather. The damp fruits or seeds should be spread out on the floor until they dry. Generally seeds should be separated from its husk or from its coat etc. Bigger wings of seeds can be broken off. The seeds are stored for varying length of time after harvesting.

Many kinds of seeds are stored in bags. Longevity under these conditions depends upon the humidity and temperature of the storage atmosphere. Improved seed storage can be achieved by drying the seeds, then storing

them in humidity controlled rooms. Dry seeds may be kept in sealed moisture resistant containers.

Low storage temperatures down to freezing or lower might be desirable. Below freezing temperatures can be used for very long storage. The most effective storage procedure is to dry the seeds to a low moisture content and place them and store them in low temperatures.

Dormancy : Ripening of seeds includes the development of internal mechanisms that control the onset of germination, so as to coincide with favourable environmental conditions. Seed dormancy results from a number of different physiological causes, such as

1. Due to the non-living external seed covering preventing water absorption by embryo, expansion of embryo, etc. thus the germination is delayed.
2. Germination is regulated by the inner tissues of the seed.
3. Both the above causes may combine together and regulate the germination.

Ecologically, germination controlling mechanisms appear to have risen as adaptations for natural survival. Germination depends upon the external or environmental conditions also, like light, temperature, water, aeration etc.

Conditions for Germination

1. Viable seeds
2. Internal conditions should be favourable for germination; physical and chemical barriers to germination must disappear.
3. Presence and appropriate environmental conditions like water, temperature, oxygen supply and light.

Preconditioning seeds to stimulate Germination:

There are number of methods/treatments to seeds, by which seeds are stimulated to germination in presence of all suitable environmental factors.

1. Mechanical scarification :- This is done to modify hard and impervuious seed coats. Scarification is any process of breaking, scratching or mechanically altering the seed covering to make it permeable to water and gases.

Rubbing the seeds on sand paper, cutting with a file or cracking the seed covering are some useful methods. Tree seeds may be tumbled in drums lined with sand paper on in concrete mixers. Care must be taken not to injure the seeds.

2. Soaking seeds in water :- Soaking seeds in water is done to modify hard seed coats, soften seeds and reduce the time of germination. Some seed coats can be softened by placing the seeds in hot water, with a temperauure 70°-100°C and allowing to soak, in the

gradually cooling water for 12 to 24 hours.

3. Acid scarification :- This procedure is useful in modifying hard or impermeable seed covering. Soaking in concentrated surfuric acid is effective in doing this. Dry seeds are placed in glass or earthenware containers and covered with conc. Sulfuric acid in a ratio of about one part seed to two parts acid, the length of treatment should be carefully standardised, depending upon temperature, the kind of seeds, quantity of seeds, etc. At the end of the treatment, the acid is poured off and the seeds are washed to remove this acid, the seeds are washed in cold water and can be used immediately or dried and stored.

4. Time of planting :- Seeds are planted when the environment provides the necessary conditions. Apart from these, some seeds germinate after storing them for a certain period of time in dry conditions; chemical stimulants are used; some seeds require exposure to light and low temperatures before germinating.

Before sowing the seeds, the seeds have to be tested for their viability - or the quality of seeds, on which the germination depends. There are some easy methods of testing the seeds.

1. Floating test :- The seeds, which are to be sown are put in a bucket of water. The seeds which do not

float or sink are said to be of good quality and can be used for sowing. The seeds which float have to be discarded as they are not healthy.

2. Cutting test :- From the seeds lot a sample is selected and tested by actually cutting open the seeds to see the development of embryo.

3. Biochemical staining test :- A sample from the seed collection is tested by treating them with 1 percent colourless solution of 2,3,5-triphenyletetrazolium chloride which will stain the living embryo and if the embryo is dead, it will not be stained.

10.2 Other Plant Propagules

Plant Propagation from Stem cuttings/stumps:-

Propagation of plants can be done by planting stem cuttings. Species of Ficus, Glyricidia, Erythrina, Morus, Bombax, Moringa, Vitex etc.

Cuttings may be from branches or from the roots and shoots. Cuttings of about 23-25 cm. portion of branch of about thumb thickness are made; a slanting cut should be made at the both ends and the ends should not be mutilated. The cuttings are placed about 1/ cm. under-ground in holes or pits. It is important that the exposed portion should have at least one bud. Root and shoot cuttings are commonly used in case of Teak and

Shissam, Cuttings are made of 18 cm. root and 5 cm. shoot. Side roots are all trimmed. The cutting is placed 18 cm. underground and soil packed firmly all round. In some cases large cuttings can be used. This will, however succeed if there is enough moisture in the soil. Stream sides can be afforested in this manner. The operation consists of preparing large sticks - 2 metres long and 10 cm. thick, and pressing them upto about 45 cm. in prepared holes, or pits and well compacting the soil around the planted portion. The sticks will throw shoots soon after the rains start, if the planting is done before monsoon.

10.3 Nursery Practices

Artificial regeneration or the renewal of the forest crop can be undertaken by sowing seeds directly on the field, planting seedlings or any other method. Though seeds are directly used under a variety of conditions for raising forest crop, the present trend is to grow seedlings in the nursery and plant out them in the field. This enhances the establishment of seedlings and thus growth of forest plantations. This practice also saves wastage of precious seed material. Hence, nowadays a greater emphasis is on the establishment of nursery for producing the planting stock of our choice.

Nurseries are the areas where the plants are raised

for eventual planting out. Nurseries occupy an important place in artificial regeneration. More than half of the total success of a tree plantation depends upon the stock produced in a nursery, the vigour and quality of seedlings. On the whole, success of a plantation depends upon the success of a nursery. The whole success of nursery depends largely on the skill and knowledge of staff supervising it.

There are some important factors to be considered while establishing a well managed forest nursery; like selection of site, compliments of equipment and staff, protection, proper water facilities etc.

Selection of Site :-

This is of a great importance. Nurseries should be selected on the best available soil, preferably on sandy loam, or loamy sand. Water facility is one of the important factors in locating a nursery. The nursery should be sited near to a perennial water source, in order to have a good irrigation facility. Good drainage is very essential in the nursery. A plain or a valley is most desirable. A ground with a slope below 5° is most suited. A more slopy land would be expensive in terracing. For, above all, a nursery should be centrally located and easily approachable.

A nursery should consist of a permanent staff of

skilled labourers, and compliment of equipments, machinery, fencing etc. The success of a nursery depends largely on the skill and knowledge of staff supervising it.

Area of Nursery:-

The area of a nursery depends upon the species to be raised, time the plants are to remain in it, and area to be planted up. The area should be substantially large to accommodate roads, irrigation channels or pipe lines, paths etc. Approximately an area of one acre is required to raise about 2.5 lakhs of seedlings in polythene bags of 13 x 20 cm size.

Approximately the following relation can be made between the land area required and number of seedlings raised (in polybags of 13 x 20 cm. size).

	Seedlings raised	Land area
1.	5,000	50 sq.metres
2.	10,000	100 sq.metres
3.	30,000	300 sq.metres
4.	50,000	500 sq.metres
5.	1,00,000	1000 sq.metres
6.	2,50,000	4000 sq.metres

Fencing:-

Once the suitable site has been selected, the area should be rectangularly demarcated and properly fenced.

Fence can be put by using wooden poles or stone pillars and barbed wire. Total cost for barbed wire and stone pillars around an acre will be about Rs.3338/- . The labour cost is about Rs.200/-

But as the nursery is a permanent establishment, a more durable and permanent fence is most appropriate and economical. For this a trench can be put around the nursery. A trench of 0.75 M deep and 0.75 M wide is dug and on the trench a live fencing can be established by planting either Agave, Glyricidia, Acacia, Casuarina, Bamboo species or the mixed planting of these. The cost regarding the digging up trench of above dimension around an acre area will be about Rs.1024.

The tender seedlings serve as very favourite food items for many wild animals like wild pigs, deers, hares, monkeys, cattle etc., These cause sometimes heavy damage to the nurseries. The live fencing would keep away these animals to some extent and live fencing also serve as barrier against heavy wind causing soil erosion.

Lay out:-

It is most appropriate to divide the nursery into rectangular blocks. In between these blocks, the irrigation channels/pipelines, paths are to be accommodated. These blocks are further subdivided into smaller blocks. Irrigation channels or pipelines should run along the paths.

When a nursery is developed on a hilly area, the land should be terraced, so as to accommodate at least one bed. The beds should be laid in the east-west direction. This would facilitate uniform light for the seedlings. The cost of terracing depends upon the nature of land.

Soil Preparation :-

Though it is preferable to raise the seedlings in containers, seedlings are also raised in beds. Before the laying out beds, the soil is dug to depth of 0.3m to 0.45 m, so as to remove all stones, roots etc. Gravelly materials are removed. For levelling an area to lay one bed, one man day is required. One bed is of a dimension of 40 ft x 4 ft. Soil, sand and manure are required in the formation of bed. At first, three layers of these ingredients, each of 2.54 cm. thickness are laid and are thoroughly mixed. About 150 kgs. of each ingredient are required in the formation of one bed. One man-day is required to mix and form one bed. The beds are enriched by application of manure both organic and inorganic in order to correct nutritional disorders. An admixture of charcoal dust and ash is mixed with soil to correct acidity and to keep away the nursery pests.

In moist areas, nursery beds are raised 10 to 15 cm. above the level of the ground. This will help in better drainage and prevent water stagnation. The raised beds

are supported by bamboos, bricks etc., preventing the beds from crumbling and eroding. In dry areas where the moisture conservation is needed and on some occasions when the seeds sown on the beds are to be kept wet, the beds are kept 10-15 cm , below the ground level. Thus beds may be raised or sunken depending on rainfall and soil moisture.

The surface of beds is preferably flat. A top dressing of river sand is beneficial, it prevents caking of top soil during rains and also accelerate germination of most of the species, e.g., Casuarina, Terminalia spp. etc.

The size of beds varies from locality to locality. In general, beds are 1.2m wide and 12.2 m long or the standard size of a bed is 12.2 x 1.2 m.

Primary Nursery Bed:-

This is the one, on which seeds are sown first and allow them to germinate. Then germinated ones are transplanted on the secondary nursery bed. This will help in raising the required number of seedlings by raising only the germinated seeds. One bed of 40 ft. x 4 ft. size can produce 2,000 to 10,000 tender seedlings for transplanting, depending upon the size of the seeds.

One person can sow the seeds on three beds of 12.2 m x 1.2 m size in one day, and cover them with paddy straw. One head load of paddy straw costing about Rs.5/- is needed to cover one standard bed.

After the seeds have germinated, they are transferred to the secondary seed bed. Wherein each seedling is given more space till they are planted out. Each seedling is spaced at 4-6 in. from the other and one bed can accommodate about 600-700 seedlings. 1,000 seedlings can be transplanted by a person in a day.

In some cases, seeds are sown on secondary seed beds directly.

Sowing of seeds:-

Before sowing of seeds the beds are watered lightly. Seeds are sown in drills running across the width of the bed. Sowing in rows is preferred. This would make weeding an easy job. Spacing of drills depends upon the species, and it varies from 8-25cm. In each row seeds are spaced at 12-15 cm. and thicker on primary seed beds.

Seeds should not be sown much deeper, or kept on the surface. Generally seeds are sown to a depth such that the depth of soil above the seed is not more than the minimum diameter of the seed.

Seed rate or the density of sowing should be carefully decided, considering the germination percent, growth rate and space reguired for development of seedling. If the seeds are sown densely the seedlings after the germination are thinned out by transplanting some of them on to other beds or containers.

After sowing the seeds in the drills, they are covered with soil by pushing the soil on both sides of drills over the seeds lying in it. In case of smaller seeds, it is better to cover them lightly with sand or leaf mould or soil. Seeds are to be protected against the attack of birds, rodents, insects etc. by protective covering and by using insecticides. Dry grass is used to cover the seed on the bed; this would enhance the germination also.

Irrigation:-

Proper irrigation is an important operation on nurseries, and should be carefully supervised. As it is seen in nature, most of seeds germinate during monsoon rains; so the seeds are to be kept moistened. It can be noted that over watering is also harmful as it is so with under-watering. When the seedlings are crowded and over-watered, it would cause decay of stem and roots-damping off.

Till the seeds start germinating, they are watered twice a day. After germination watering gradually can be brought down to once in a day. When the seedlings attain sufficient growth and height, watering should be controlled to harden off and to control growth.

Irrigation is usually carried out by using:-

1. water cans or rose cans - watering is done manually;

2. by flooding the seed bed and allowing water to penetrate the beds;

3. by sprinklers - though it is useful, a lot of investment is done and equal watering is a problem.

By using rose cans, one person can water 5 standard beds twice in a day. If the nursery is equipped with a pumpset, 15 beds can be watered twice a day with the help of pipe-lines and sprinklers.

Weeding:-

A lot of weeds do appear on nursery beds, as beds have plenty of manure and moisture. Weeds compete for food and light with the seedlings. Weeding is a very important operation and should not be neglected or delayed. Weeding operation is carried out with the following precautions:

1. care must be taken not to disturb the seedlings;
2. the soil around seedlings is firmly pressed by holding seedlings between two fingers, while pulling out weeds;
3. weeding is carried out when the soil is wet - this would avoid the removal of soil with the roots of weeds;
4. the upper surface of bed is always marked up to reduce evaporation of moisture by breakings up capillary action;
5. the seedlings are thinned out if they are crowded.

The manpower for weeding operation depends upon the condition of the bed - more growth of weeds, needs more

manpower for weeding. On an average, one person can remove weeds from two beds in a day.

Shading:-

Seedlings are provided with shade in most cases, the main objectives being:

1. to give young seedlings protection against desiccation due to hot sun;
2. to protect seedlings from heavy rains and hailstorms and the splash of rain drops thus preventing the exposure of roots.

Shades can be made out of cheap materials which are locally available like thatch, mats etc., supported by poles.

The seedlings, which are transplanted in bags of secondary beds have to be provided with shade preventing heavy mortality.

Shading is gradually reduced and removed completely in order to make the seedlings hardy, enabling them to withstand the adverse conditions of field when they are planted out.

One man day is required to put up necessary structure for providing shade for 1000 seedlings in bed, if all the materials are ready in the nursery place. The material cost varies according to the availability of materials like areca leaves or coconut sheath, poles or stone pillars etc.

Plant containers:

The practice of growing seedlings on beds now a days has been taken over by growing the seedlings in plant containers, by using leaves of Bauhinia (leaf cup or cylinder), moss cylinders, baskets of bamboo stripes, tubes of tiles, bamboo, paper, bark of Betula, earthen pots etc.

This method of growing seedlings in containers has many advantages:

1. some species, if planted with naked roots do not survive and or if they could survive, they obtain poor growth. Seedlings have to be planted with naked roots, when they are grown on beds. On the other hand if they are planted with a ball of earth, they perform better and this is possible when seedlings are raised in containers;

2. seedlings get plenty of nutrients and less competition for nutrients from other seedlings;

3. operations like weeding, watering, etc. will be easy to carry out and are more efficient;

4. there will be very little damage to the seedlings during the transplantation of seedlings.

Plant containers are defined as containers in which seedlings are raised from seeds or into which plants are transplanted from primary nursery beds.

Various containers used in raising the planting stocks are:

1. Planting bricks

These are raw bricks made of clay, farmyard manure, and sand mixed in equal proportions. Water is added to the mix to make a thick paste and is made into a mould designed for the purpose. The brick can be 25 to 30 cm high with 10 cm x 10 cm at the top and 15 cm x 15 cm at the base. The size of the brick varies from place to place. At the top a hole of 2 cm diameter and 6-10 cm deep is left for putting soil and seed or seedling. Then it is sun-dried. Seedlings are raised in these bricks.

2. Dona

It is made of leaves of Bauhinia vahlii used in Madhya Pradesh for teak seedlings. It is a leaf cup, in which seedlings are raised.

In Bengal, bottomless leaf cylinder is used for the purpose. It is made of air dry leaves of Ficcus bengalensis, Diospyros melanoxylon or Shorea robusta.

3. Moss cylinder or fibre cubes

Cylindrical cubes of moss, about 1.5 cm in length and 5-8 cm. in diameter are used in Ootacamund for planting Eucalyptus species.

4. Baskets :- Baskets of bamboo strips or Tamarix are used for raising seedlings.

5. Tubes :- Tubes of earthen tiles, bamboos, paper, tin and Betula bark are also used as containers. Tubes are tied

with threads or ropes, or wire. Betula, which are available locally is used in Manali in Himachala Pradesh.

6. Earthen Pots :- They may be with or without bottom. These are relatively costly and also their weight increases the cost of transport also.

7. Polythene bags - Polythene bags have nowadays replaced almost all the containers and are being used for raising seedlings on a large scale.

Polythene bags are used because they are cheap, easy to handle, durable, light and strong. Polythene bags are made up of transparent white sheet or black opaque sheet. Bags are perforated at the lower side of bags for aeration and drainage. Bags commonly used are of gauge 200 and 250 and their sizes vary depending upon the species, and the desired growth of seedlings in the bag.

In general, bags of 13 x 20 cm are in use. Now, bags of 15 x 23 cm. and 23x28 are also used. At today's rate kilogram of polythene bags costs about 25 rupees. About 250 bags of 13 x 20 cm weigh one kilogram.

The ingredients have to be filled up in the planting containers. They include sand, soil and manure and together make nursery soil when mixed correctly.

Soil is made up of one part of well sieved forest soil, one part of sand and one part of manure. These

ingredients are mixed thoroughly and filled in plant containers. While filling, there should not be any gap left in the containers (bags). These bags are arranged in rectangular blocks in the nursery. The number of bags in each block varies. Usually 1500 bags are arranged in one block. These are watered, before seeds are sown into them. Seeds are either directly sown into these containers or the pre-germinated seedlings are transplanted into them from the primary nursery beds. All the usual operations like weeding, watering etc. are carried out regularly.

Expenditure is incurred in levelling the ground, procuring the ingredients, filling up bags, arranging them in order. On a suitable area, without much elevation, one man day is required to prepare an area accommodating about 5000 bags.

The cost, regarding the ingredients like soil, sand and manure varies from locality to locality. Also the transportation costs also vary a great deal according to the availability of these ingredients.

If the ingredients are locally available, then two labourers can procure about 4 cart loads. One cart load of manure costs about Rs.100 to Rs.130 in the local market.

With one cart load of nursery soil - mixture of soil, manure and sand in the ratio of 1:1:1.5, about 2.75 bags of 16x23 cm size are filled up or about 525-550 bags

of 13x20 cm size. The hire charges for cart is Rs.60/- per day.

Two labourers can mix and fill up ingredients into 1000 bags of 13x 20 cm. About 3000 bags can be arranged neatly in the nursery by 3 labourers in one day.

After the arranging polybags in blocks, seeds are sown into bags. Usually two seeds are sown in each bag to secure at least one to be germinated and are sown at the centre. The germinated transplanting material can be transplanted into these bags also.

One man day is required to sow in 1,500-2,000 bags and about 1000-1200 seedlings can be transplanted into bags.

Watering - two labourers can water about 6000 seedlings twice a day by hand, using rose can. With the help of pumpset, pipes two persons can water about 10,000 seedlings twice a day by using pipe fitted at the opening with perforated cap.

Weeding, again, depends upon the growth of weeds. One person in a day can remove weeds from about 2000 bags.

Once the seedlings start growing in the bags, the bags are to be shifted from one place to other within the nursery itself. This will prevent the roots of seedlings from piercing through the bags into soil. Polythene sheet are also used for this purpose.

Polythene sheets are spread on the ground and a layer

of sand is put on the sheet. Then the bags with the seedlings are arranged on it, from another place. While doing so, the seedlings are graded according to the growth of seedlings. Two persons can shift and grade about 2000 polybags in a day. This practice would also induce plants to develop compact, bushy root system, instead of long tap roots.

Transplanting:-

This is a very crucial and an important operation. Seeds, more so, when they are small, are sown on nursery beds. After the seeds start germinating, these are transplanted into the bags.

The required number of seedlings can be raised in bags and unnecessary maintenance cost of empty bags in the block will be prevented. Root system should not be damaged while transplanting which would cause heavy mortality.

Application of fertilisers :-

Apart from mixing the nursery soil with manure, chemical fertilisers can be used to supplement nursery soil. The growth of seedlings is promoted by regulating the quantity of manure and method of application.

When using species which have mycorrhiza in their roots, the soil has to be introduced with appropriate mycorrhiza for a good development of seedlings.

10.4 Planting in the Field

1. Fencing :- Once the area to be planted is selected, it should be fenced. It is universal experience that the plantation work shouldbe protected from grazing by animals, and steps also have to be taken to keep them away. Even with hardy species, thorn species, or unpalatable ones, damage is done by trampling and breakage, and browsing. Plantations therefore must be protected against all kinds of animals notably bear, wild pigs, percupines etc.

The seedlings, planted on the site need protection at least for first three years from grazing.

(a) Live fence - Close hedge of easily propagated species provides an adequate protection, if properly established. The species should be unpalatable to cattle, throny, fast growing, easily propagated from cuttings. Usually gaps are formed in one way or the other; so an effective maintainance is necessary. Species used are: Durantha, Agave.

(b) Brush-wood fence - By using wooden poles and refuse from the clearing of plantation, a reasonably efficient fence can be constructed. But the maintenance is difficult.

(c) Stone-walling - A stone wall about 1.2 m high is quite effective against horned cattle. It has to be properly maintained. The stonewall is preferred where the suitable stones are available and labour rates are low.

(d) Barbed wire fencing - Barbed wire supported by fence posts serve as a good fence. The posts and wire should be strong and durable. The number of strands and the height vary with conditions. But in all cases, they should be near the ground to keep away as far as possible, pigs, sheep, goats, calves etc. with 4 strand and 1.2 m high fence from the ground might be effective. Wire mesh is also used instead of wire in some cases.

(e) Trenches - Where the depth and nature of soil permits, a trench can be an effective protection at comparatively low cost. The trench can be 1.2m deep, 2m wide at the top and 1m wide at the bottom of the trench. The excavated soil is filled up along the inner edge. A live fence can be established on the ridge.

Soil and water conservation measures are two critical factors for plantation establishment. In the hilly regions during the dry period of the year, soil layers at the top tend to become compact and dry. Thus it loses its capacity to absorb moisture at the onset of rainy season. Destruction of vegetation, total or partial has led to conditions of severe soil erosion and depletion of catchment efficiency. The high intensity of rainfall can exceed the capacity for infiltration percolation and hence disposed off subsequently through subsoil drainage.

The development of techniques to reduce run-off can

make afforestation a success. The basic aim of soil working and water conservation techniques is to creat conditions by which water can be retained on the site and surplus discharge through subsoil drainage. Proper soil working to trap water and prevent erosion can achieve stability of site.

Soil preparation / Soil working :

After clearing the area to be planted soil working is done in February-March preceeding the planting season. Pits of required sizes are dug. In case of saline and alkaline soils, the soil of the pits are replaced with good soil. The size of the pits in different areas varies to some extent. In water logged areas planting is done in mounds upto 1m height. Therefore during the preliminary survey of the area, methods to be adopted in pitting and planting should be decided. A planting map should be prepared for the selected site with species to be planted in different parts. Here, a treatment map plays an important role in the success of a plantation.

There has been little systematic studies regarding the efficiency of various soil working techniques. The effect of soil working on soil properties and the requirements of species for soil moisture air, nutrients etc. are not known precisely. So all methods or techniques available are to be carefully tried out in the field.

In a given locality two main factors the rain fall and soil primarily determine the soil working technique to be adopted. Thus suitable soil working technique for a locality is governed by the pattern of precipitation, the topography, the geology and the morphology of soil profile, The significance of precipitation pattern like the amount of rain, the duration of rain, the number of rainy days, the intensity and frequency of precipitation - is very importatt to devise suitable technique. It should ensure the maximum availability of moisture to plants. Topography is very important factor in the development of soil profile affecting soil wash, run-off and the applicability of soil conservation and afforestation measures.

Some of the common soil working methods are mentioned below:-

1. Pit - This technique is recommended for planting. Pits are marked and dug on a planting site. The soil from the pits are heaped up on a side of the pit for weathering. After weathering the dug soil is filled back into the pit. Normally pits of the size 30cm x 30 cm x 30 cm are used for planting. Pits can be dug after the first showers, or after monsoon. The pits can be dug for the next year planting.

The following advantages can be mentioned of this technique.

1. this would enable rainwater to penetrate deeper so that moisture is retained in the soil.

2. enable seedlings to develop long tap root;
3. improve saeration of soil;
4. get rid of roots of weeds;
5. accommodate root system of plant in case of entire planting.

1. (a) Ordinary pit - The pit is of the size of 30cm x 30 cm x 30 cm with the sides slanting. It has a high crest and a water storage ring. The deepest part of the ring should be rather far away from the highest part of the crest/mound. This minimises the waterlogging and also the concentration of salts near the seedlings.

This type of pit is recommended for clayey and alkali or saline soils in almost all rainfall classes. This type of pit is also suitable for sandy soils. In a sandy substratum, the soil can be improved by incorporating partly decayed organic mulching material, because it increases its water retention capacity.

(b) Saucer pit - This type of pit is suitable for all types of loamy soil in all annual rain fall classes. The pit is made in the centre of a saucer of 1m. radius prepared by giving the soil a slope from outer periphery towards the centre. The pit which is made in the centre of the saucer, is filled back with dug up soil to form a mound. If the soil is sloping, a crescent ridge is made on the lower side to prevent water from flowing down. In

a sloping area slope is not given, as it has a natural inclination.

(c) Ring pit - This type of pit is made by making a circular trench about 20 cm away from the pit. The circular trench collects rain water for supply of moisture to the plant. The pit is filled back to make mound but its crest should not be high to enable the main mass of roots to be about 30 cm below the surface where moisture occurs in case of sandy soils. This pit is recommended for sandy soils.

2. Ridge-Ditch :- It is a partly filled in trench. Normally it is recommended for sowing on sloping ground. But it can also be used for planting. The sides of ridge-ditch may be vertical or slanting. Size of the pit can also be variable according to the amount of rainfall and soil conditions of the locality.

3. Shelfed-Trench :- In this type of soil working a shelf is made on one side. It is suitable for those soils which contains very fine clay. The shelf can be made on the lower side or on the upper side. The size of the pit again can vary with rainfall and soil conditions.

It is used on sandy and gravelly soils in areas with low rainfall.

4. Double Trench :- On stony and detrital slopes whose water holding capacity is extremely small and surface run-

off and subsurface drainage is very high, a large quantity of water has to be impounded in an unfilled trench and this water has to be allowed to seep below the filled soil of another trench.

5. Trench Ridge :- In this case, a trench is dug and kept unfilled for water storage and the dug up soil is used to make a ridge near it on the ground; the ground can be loosened to increase the depth. The ridge is used for planting or sowing. Trench ridge can be shallow or deep. It is suitable for soils with salt contents because it provides for efficient leaching of salts from the seed bed.

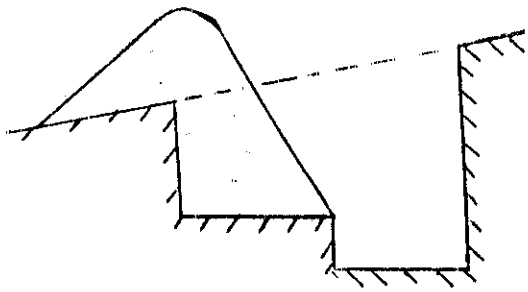
6. Trench Mound :- A mound is made in the middle of a trench. The surplus soil is made into a sloping ridge on the lower side of the trench. These mounds are suitable for gently sloping lands. This type of soil working is used in areas with low erratic and badly distributed rainfall.

In all the cases, the soil preparation is done by manual labours. But in case of large scale afforestation work, mostly in plains the soil working is done by tractors ploughs, subsoilers, harrows, ridgers etc.

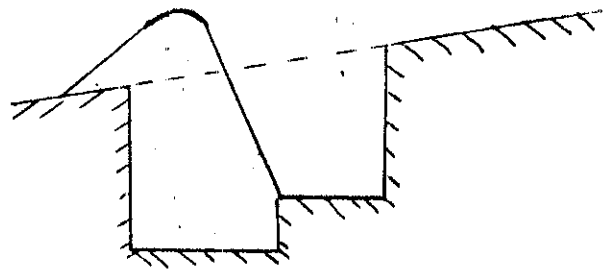
Sowing :- For easy execution, economy and labour, direct sowing of seeds is practiced. The time of sowing is very important. With sowing of seeds on the field, there will not be any disturbance to the roots of seedlings as it

FIG 10.1 · CONTD.

3. SHIFTED TRENCH

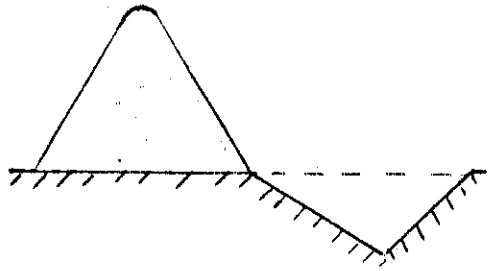


3.1 SHALLOW · FILLED

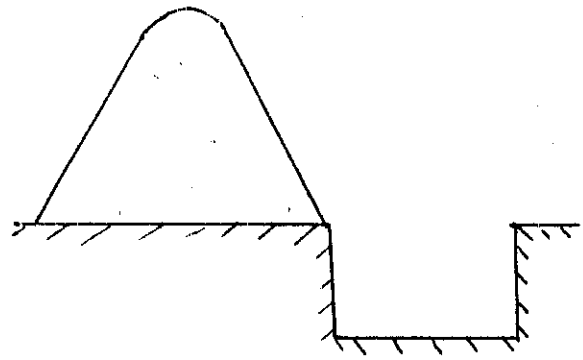


3.2, DEEP FILLED

5. TRENCH - RIDGE

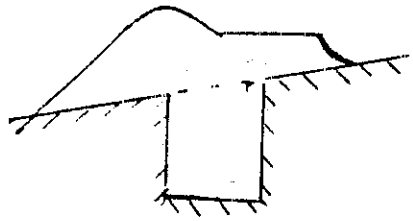


5.1. SHALLOW

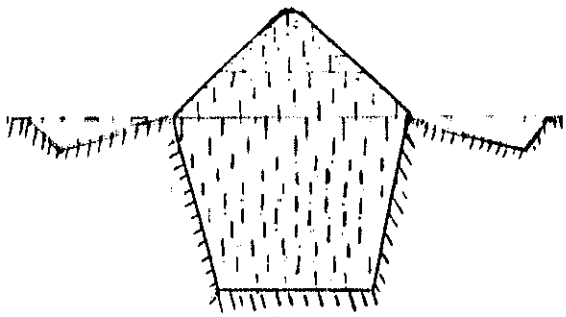


5.2. DEEP

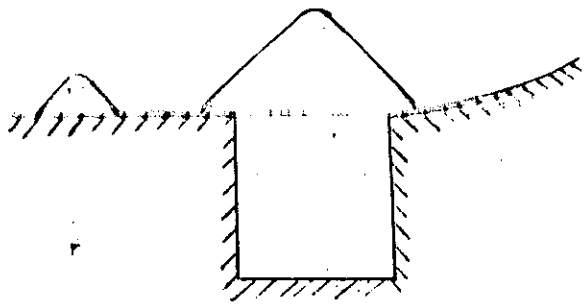
6. TRENCH MOULD, (CROSS SECTION)



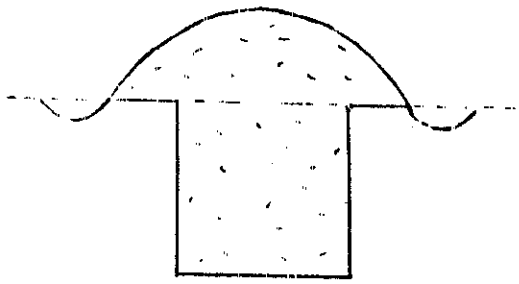
Soil Working Techniques (Diagramatic)



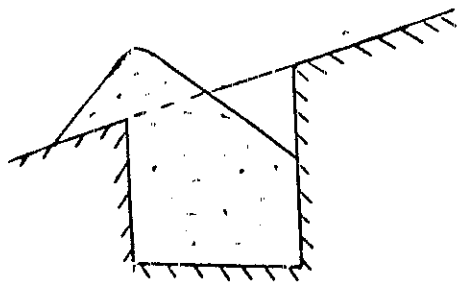
1A, Ordinery pit



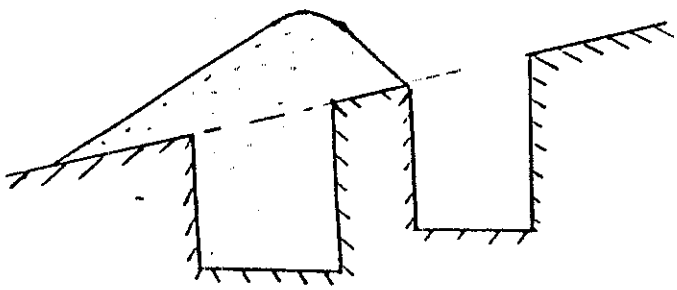
1B, Saucer pit



1c Ring pit



2. Ridge - ditch



4. Double Trench

happend in planting. But sowing requires a large quantities of seeds the birds and animal may distroy or eat up the seeds sown.

Planting the seedlings has many advantages over the direct sowing of seeds. Most important is that success is relatively ensured in case of planting. So, these days planting of seedlings is more in practise.

Planting :- Some species do best by planting and are raised by planting. Planting is normally done with the seedlings raised in nursery. Natural seedlings (wildings) are also used some times.

Season of planting :- The season of planting depends upon the method of planting and local climatic conditions. So, planting can be of following kinds, depending upon the season.

1. Monsoon planting - This is the most common season of planting in areas receiving rains from south-west monsoon. Planting, in this season is done as soon as the rains fully set in and the soil is soaked to about 30 cm depth. Throughout India planting is carried out in the months of June and July. On the Western Ghats where the rains are very heavy, the planting should be done before July, or after August, when the wettest period of monsoon is over. The planting should not be done when the soil may be wet and sticky.

2. Premonsoon Planting - Where irrigation is possible for where summer is accompanied by fairly good showers, it is advantageous to plant as early in the growing season as possible. Eg. Morus alba is planted in February in North India.

3. Winter planting - Some hill species are planted before snowfall for better results. Most of the broad leaved species in the western Himalayas, Bengal are planted in winter before show fall and when these plants are leafless. Eg. Toona, Chikrassia, Dalbergia spp. etc.

4. Spring planting - Spring planting of conifers is done in parts of Kashmir, where monsoon does not reach.

Size and Age of Planting:

Generally the smaller the plants the easier is planting with naked roots. But smaller plants are difficult to handle and are damaged in many ways, and even if planted the mortality will be high. Big plants can also be planted with naked roots. Thus the size of the planting stock depends upon the method of planting. The age of the seedlings depends upon the rate of growth.

Method of planting :- Following methods of planting are used commonly:

1. Entire planting :- In this method, the entire plant is lifted from nursery and planted out in the field. Entire planting is done in the following ways

(a) With naked roots,

(b) With roots covered with soil.

1(a) Entire planting with naked roots :- Plants for naked root planting are taken out from the nursery bed when the monsoon has set in well and all preparation for planting at the site have been completed. Soil round the root is dislodged and plant is taken out, without damaging the roots. Plants are kept in shade. Leaving a few leaves in the leading shoot, rest of the leaves are removed to reduce transpiration. The plants removed should be planted out the same day. The plants are lightly tied into a bundle. To keep the roots moist, a little wet earth is put round the roots and are wrapped with gunny cloth. Bundles are kept in vertical position in baskets and transported to planting site.

Pits should receive the entire root system without doubling the tap root. The plants are held in a vertical position at the centre of the pit. The collar should be kept about 10 cm above the ground level. Keeping the entire root system in their natural positions, the soil should be pushed from all sides. Soil is pressed so that there should not be any empty space in the pit. Plants should be covered upto the collar region keeping the soil sloping in all directions and should be well pressed. Care should be taken not to expose any roots and not to bury any portion of shoot, in the soil.

1(b) Planting with roots covered with soil:-

(i) Planting seedlings raised in nursery with ball of earth - Many species can not survive the shock of naked root planting. They have to be planted with the soil in which their roots are growing without causing any damage to them. The seedlings are planted with a ball of earth of nursery soil, hence called ball planting.

(ii) Brick planting - It is planting of seedlings raised in planting bricks.

(iii) Planting of seedlings raised in containers - Depending upon the kind of containers used, this planting is called dona planting, basket planting, pot planting, tube planting or bag planting.

Container plants don's require any special preparation except that these should be irrigated before being transported from the nursery. Fragile containers should be handled carefully to avoid damage during transport eg. raised in moss, dona etc.

For planting, containers have to be classified into two categories, eg. those planted with containers and those without containers. Donas, moss of fibre cubes, Betula bark tubes, baskets, belong to the first category which is planted with containers. Earthen pots, metal tubes belong to the category in which the containers are removed before planting. In case of polythene bag plants,

bag is torn out amd ball plant is planted. Sometimes only the base of bag is torn.

Apart from sowing and planting the seedlings, planting of stumps or root and shoot cutting is also practiced in raising plantations.

Seedlings are taken out from the nursery beds without damaging the roots. For making stumps, the seedlings having 30 cm long tap root are selected. The collar diameter should not be less than 1 cm or greater than 2 cm After selection, theshoot should be cut off leaving only 2 cm to 3 cm portion of shoot. All the roots should be pruned. The bark of the taproot should not be damaged. The tap root should be cut at a distance of 20 to 22 cm from the collar. These stumps are dipped in a paste of soil and packed; and are transported. Stumps are planted in pits.

Irrigation :- Watering a plantation is difficult and also expensive. Hence, it is not usually done. But in some cases it is done like in the (1) dry tracts where irrigation is possible, (2) road side avenue planting and (3) Casuarina plantation in sandy soils.

But in all the plantations, some of the species of plants do perform best, if they are provided with irrigation, in the initial establishment eg. Vateria indica.

Application of Fertilizers:

Fertilizers have not been used in the forest plantations so far to any significant extent, because they were raised on fertile forest lands. But now the plnntations are raised in marginal soils and on some of the most degraded soils; so application of fertilizers has become necessary to achieve quick and better growth. The requirements of species and the fertility status of the soil have to be determined prior to the application, to determine the quantity to be applied.

Application of Diammonium Phasphate to newly planted seedlings has shown good results. A quantity of 10 gms to each plant is found sufficient. Also, addition of neem cake and Phosphate to the soil will promote the growth of seedlings very significantly.

Weeding:

Weeding is an important operation. Weeds can be destroyed at the time of soil preparation. But they appear as monsoon sets in.

Weeds affect the growth of seedlings especially when the plantations are to be established by direct sowing of seeds. In the first year the weeding has to be done in the plantation 2 to 3 times.

Fire and General Protection :

The plantations have to be protected against fire

and grazing. Cattle and other animals can be kept away only if the fence erected is maintained properly. A guard/watchman can be appointed to maintain the fence.

From January onwards, the plantation has to be protected against fire by burning fire lines.

Beating up :

There are always failures among the planted seedlings on the plantation. These pits are replanted with seedlings. This operation is called beating up or casuality replacement or restocking blanks in an artificial regenerated area. Restocking can be taken up in the same year before the monsoon is over or in the following year.

Soil work:

After planting is over, the soil round the seedling is loosened and put around the seedling. It will help soil aeration and conserve soil moisture by breaking capillary action in the soil particles.

The plantation should be.protected at least for 3 years against weeds, fire and grazing.

10.5 AFFORESTATION ON DIFFICULT SITES

Some of sites pose difficulties in establishing the plantations. For afforestation programme, special attention should be given to these areas like ravine lands, denuded hills, shifting sands, water-logged areas etc. Those areas are characterised by special topographic

features and certain factors of their own, which require proper planning in the choice of species and afforestation techniques.

1. Ravine Lands:

Indiscriminate destruction of vegetation, improper cultivation of lands and neglect of suitable soil conservation measures in various parts of western ghats have led to the formation of gullies and ravines.

When ravines are formed they continue to cut backwards and even destroy the vegetation cover on the above lands. Soil is sandy to clay, mixed with lime. This prevents the roots of plants to reach soil moisture and also prevents rainwater to infiltrate to deeper layers. Due to excessive grazing, fire and destruction of vegetation, these areas are subjected to active gully erosion.

Ravine reclamation has to be tackled on a catchment basis. Soil conservation measures, above the gully heads where the land is under cultivation and also in the active gully area should be taken up simultaneously. Efforts should be made to prevent water from coming into ravine area. The catchment area should be treated, which is the most important.

One of the pre-requisites for reclamation of ravines is to protect these areas from grazing, fire and felling of trees. Catchment areas of ravine are attended first

to prevent uninterrupted flow of water towards the head of ravine. For this, contour bunds are put up at suitable intervals according to the slope of the land. If the topography of the site is undulating and steep , contour trenches of about 3 metres x 45 cm x 30 cm are dug at suitable spacing depending upon the degree of slope. On the ridges, suitable grasses/legumes are sown. Ridging at the gully heads is done by digging continuous contour trench above the gully heads; run off should be diverted away from the active gully head. Deepening and extension of gullies is checked by erecting check dams of suitable materials and design; and gully plugs.

The afforestation programme should bewell planned considering various factors. Special consideration for planning afforestations of these lands are soil fertility, sandy layers, soil moisture, concentration of salts, topography and other biotic factors. Generally these areas are poor in fertility; gully slopes are dry and gully beds may have good moisture in the soil. Thus the selection of species of plants should be made accordingly. Acacia catechu, Dalbergia sissoo, etc., which are dormant during dry summer months, should be preferred on gully slopes and humps as the soil does not contain much moisture. In the gully beds Azadirachta indica, Albizzia spp., Dendrocalamus strictus, Gmelina arborea, Pongamia glabra are planted. In clayey soils

Acacia spp., Ailanthus spp., Syzygium spp., Pongamia glabra are planted. Apart from planting the seedlings, sowing of seeds also can be taken up in trenches. In between trenches intercrop of various legumes like Puereria, Desmodium, Dolichos etc., and other grasses can be grown.

Tall and grown seedlings have better chances of success under ravine conditions. Seedlings raised in containers are preferred to the rooted plants.

The whole area should be protected against grazing and fire.

2. Shifting Sands:

Along the coasts, and river banks the soil consists of sand. These sand particles are being dislodged by the winds and also water, particularly in the absence of vegetation.

The conditions are different along the coasts and along the rivers. Hence, these two areas are treated separately.

On the coasts, the soil is sandy, and it will keep on shifting. The soil is incapable of retention of moisture. Water table is shallow and slightly brakish. Rainfall is high and weather is humid. Interference of cattle and human is quite high.

Planting is done in the pits. Soil work consists

of digging pits. Soil is immobilised by planting grasses and shrubs. Planting is done in June-July or October-November. Plants are watered for the first two or even three years.

Species recommended are Casuarina, Anacardium occidentale, Pongamia glabra, Acacia sp., Eucalyptus sp., etc. Seedlings in containers are preferred. The plantation should be protected against grazing.

Along the river banks also the soil is sandy. It is unstable and deficient in nutrients. Water table is shallow. Rainfall varies. Pressure of human and cattle is high.

Planting will be done in pits. Dalbergia sissoo, Acacia sp., Albizzia procera, Pongamia glabra, Ailanthus sp., Melia azedarach are recommended for the area sand is immobilised by planting shrubs, grasses etc.

Along the irrigation canals also, soil is sandy to clayey. Soil moisture is good and some places are water-logged. Along these canals either planting of seedlings or direct sowing of seeds in the pits can be taken up. Species recommended are Dalbergia sissoo, Melia azadarach, Morus alba, Acacia arabica, Albizia sp., Acacia catechu, Pongamia glabra, Eucalyptus spp., etc.

3. Denuded Hill Slopes

The afforestation of denuded hills is very important,

especially in the heavy rainfall tract. In these areas the conservation of soil and water forms the main basis for afforestation.

In these areas the soil is shallow and stony. Soil erosion due to heavy rainfall has resulted in the removal of most of the surface soil, leaving only the infertile sub-soil and in some places even the sub-soil has been removed. Run-off results in deficiency of soil moisture. Grazing which is the cause of denudation is another important factor and is very heavy near habitation.

Soil preparation in these type of sites is very elaborate one. Contour trenches are preferable on the slopes below 20 percent. These trenches may be continuous or interrupted. Interrupted trenches are better. Generally they are 3 metres long and 30 cm wide; the depth of trenches depends upon the average rainfall of each day in the area. In places where the soil is rocky and contour trench is not viable, soil work is done in the form of patches or pits.

The most important thing is to protect the whole area from grazing, cutting of vegetation and fire.

Choice of the species depends upon various factors. Surviving indigenous species in the area could be suitable ones. Fast growing, non-palatable species, which withstand adverse conditions of the locality should

be selected. Poineer species are suggested. Examples - Acacia sp., Prospis juliflora, Robinia Pseud-acacia, Hardwickia binata, Albizzia sp., Anacardium occidentale, Cassia siamea, Dalbergia Sissoo etc.

4. Dry Areas

Soil is of various types and is deteriorated. Rainfall is very less - 250 mm to 750 mm. Number of rainy-days is also less. Threats from human and animals are high.

Soil is dug to a sufficient depth in order to conserve maximum moisture and also for the development of root system. On the slopy area trenches are made.

Species to be selected are drought resistant and fast growing like Acacia sp., Dalbergia sissoo, Albizzia lebbeck, Ailanthus sp., Cassia siamea, Pongamia glabra, Casuarina sp., Anacardium occidentale, etc., where the irrigation is possible, here Morus alba, Syzygium sp., Eucalyptus sp., can also be tried.

5. Water Logged Areas

Reasons are many in causing water logged areas. Along the areas of canal irrigation in areas adjoining agricultural lands where the subsoil water-table steadily rises; in depressions along roads, canals, and rail sides during rainy season one can find water-logged conditions.

It is necessary to stub out all tufts of tall grasses from plantation area to reduce competition and also for fire hazards. So, two or three year old stock is recommended. Planting of tall plants is done on mounds of suitable dimensions, so that they are not sub-merged during rainy season. Adding fertilizers, insecticides is beneficial. The most safe and sound practice is to do planting in summer or atleast during premonsoon rains. This would help the seedlings to establish before the heavy rains. Drainage to remove excess water should be done.

Tree species with high transpiration rate are to be preferred. Examples: Eucalyptus, Syzygium cumini, Terminalis arjuna, Dalbergia sissoo, Pongamia glabra, Acacia catechu.

10.6 Beekeeping

Once the forests on W.G. supported rich production of honey. Many of the farmers had made it as a subsidiary occupation. Beeking in India is still largely a forest based industry. The evergreen forests were favourable for bees as permanent locations of where they produce honey and multiply in numbers.

Rapid deforestation has led to severe reduction in bee forage, round the year. This occupation can be developed by creating once again a suitable environment

for bee colonies by planting various trees and shrubs along the fences, borders, bunds, waste lands, forest lands etc., which provide nector and pollen to bees through out the year.

Beekeeping can be more productive, if the farmers introduce various agricultural crops. The flowering time of various crops will be most beneficial to beekeeping. So, both agriculture and forestry can improve the beekeeping occupation.

Besides the production of honey and wax, beekeeping has a much more important role in cross-pollination of agricultural crops. Several of our oilseeds, vegetables, legumes, fodder crops, plantation crops - like orange, lemon, coffee, cardamom etc., depend on insects like honeybee for cross pollinations which increases the production and the quality.

Beekeeping, having a large number of colonies provide self employment to the people near the forests.

Some important bee plants:

In the following list common names in regional languages are given, whereever known. The language is indicated in brackets: Eng : English ; H : Hindi; Tam : Tamil; Tel : Telugu; Kan : Kannada; Mal : Malayalam; S : Sanskrit; Guj : Gujarati; Ben : Bengali; O : Oriya; A : Assamese; Mar : Marathi; P : Punjabi.

Acacia sinuata (Lour.) Merr.

Common names : Soap pod tree (Eng); Kochi, Ritha (H); Sikikai (Tam); Chikake (Mal); Manda-otte, shigo, sige balli (Kan); Shikaya (Tel); Shikekai (Mar); Chikakai (Guj); Bhuripena, dipta, phena, saptata, vidula (S); Bon-Ritha (Ben).

Economic use : Soapnut; bark for dyeing and tanning, live fence: firewood.

Method of propagation : Seed.

Aegle marmelos (Linn.) Corr.

Common names: Baeltree, Bangal quince (Eng); Bel, bili (H); Vilvam (Tam); Koovalam (Mal); Bela, baelpatri, bilapatri (Kan); Maredu (Tel); Bel (Mar); Bil (Guj); Bilva (S); Bel (Ben).

Economic use : Fruits edible, medicinal, timber

Method of propagation : Seed.

Bombax ceiba Linn.

Common names: Red silk cotton (Eng.); Semul, semur, pagun, shembal (H); Ilaya (Tam); Elavu, pulamaram (Mal); Buruga, burla, sauri (Kan); Booruga (Tel); Lal savar (Mar); Sawar (Guj); Salmali, rakthapushpa (S); Bouro (O); Simul (Ben).

Economic use : Seed fibre; timber; avenue tree

Method of propagation : Seed.

Ceiba pentandra (Linn.) Gaertn.

Common names : White silk cotton, kapok tree (Eng); Hatian, katan, safed-simul, semibal (H); Ilavu (Tam); Panya (Mal); Dudimara, bulilurga, marali (Kan); Kateswar, Shamieula (Mar).

Economic use : Seed fibre, timber, avenue tree.

Method of propagation: Seed.

Elaets guineensts Jacq.

Common name : African oil palm (Eng)

Economic use : Palm oil from fruits, ornamental

Method of propagation : Seed

Emblica officinalis Gaertn

Common names : Emblic myrabolan (Eng); Amla (H); Nellikai (Tam); Nelli (Mal); Nelli (Kan); Usirikai (Tel); Avla (Mar); Amala (Guj); Adiphala (S); Aura (O); Amlika (Ben).

Economic use : Fruits edible, medicinal

Method of propagation : Shield budding.

Limonia acidissima Linn.

Common names : Wood apple (Eng); Kait, bilin (H); Vilanga (Tam); Vila, Vilatti (Mal); Byala (Kan); Velaga (Tel); Kavath, kavith (Mar); Kavit, kotha (Guj); Kait, katbei (Ben).

Economic use : Fruit edible; gum; wood.

Method of propagation : Seed, cutting, layering.

Leucaena glauca Benth.

Common names : Soobabul (H; Mar); Tagarai (Tam); Takaranniram (Mal); Kaniti (Tel); Lasobaval, Vilayatibaval (Guj); Rajokasundiri (O);

Economic use : Green manure, fodder, timber, firewood, etc.

Method of propagation : Seed.

Moringa oieifera Lamk.

Common names : Drum stick tree (Eng); Sainjana, senja (H); Murangai (Tam); Murunga (Mal); Kochka, nuggi (Kan); Munaga (Tel); Shevga (Mar); Sargavo (Guj); Shobonjana (S); Munagha (O); Sohanna (Ben); Saijan (A); Soanjna (P);

Economic use : Leaves, flowers and fruits eaten as vegetable; gum; medicinal; firewood.

Method of propagation : Seed, cuttings.

Pongamia pinnata (Linn) Pierre

Common names : Indian beech (Eng); Karanja (H); Pangam (Tam); Punga (Mal); Ponee, huligalli, karanj maru (Kan); Ganuga (Tel); Karanja (Mar); Kanaji, Karanki (Guj); Koranjo (O); Darkaranja (Ben); Karchew (A); Sukhehain (P).

Economic use : Non-edible oil, medicinal, timber, firewood.

Method of propagation : Seed, Cuttings.

Sapindus species

Common names : Soap nut tree (Eng); Ritha (H); Puvamkottai (Tam); Pasakotta (Mal); Anthuvala, Kugala phenilu (Kan); Kunkudu (Tel); Ritha (Mar); Aritha (Guj); Aristha (S); Muktamanji (O); poor ritha (Ben); Reitha (P).

Economic use : Fruits used as soap; timber; shade tree.

Sesbania grandiflora Pers.

Common names : Basna, bak; agusta, hatiya (H); Agathi (Tam); Agathi (Mal); Agase, kempangase (Kan); Avesi (Tel); Hadga, Agati (Mar); Agathio (Guj); Agasthya (S); Buko (O); Buka (Ben).

Economic use : young leaves, flowers and fruits eaten as vegetable fodder:, firewood.

Method of propogation : Seed

Syzygium cumini Skeels

Common names : Black or Java plum (Eng); Jamun (H); Naval (Tam); Naga (Mal); Jambul (Mar); Jambudi, Jambura (Guj); Jamo (O); Kalajam (Ben); Jambu, neralu (Kan); Neredu (Tel); Jamun (P)

Economic use : Fruits edible; medicinal

Method of propagation : Seed.

Tamarindus indica Linn.

Common names : Tamarind tree (Eng); Imli (H); Puli (Tam); Puli (Mal); Amla amlika, amlike, hunase (Kan); Chinta (Tel); Chinch (Mar); Amli (Guj); Tentul (O); Tentuli (Ben); Tetuli (A); Imbli (P).

Economic use : Fruits and young leaves edible, condiment, tartaric acid, timber, firewood.

Method of propagation : Seed.

Terminalia chebula Retz.

Common names : Chebulic myrabolan (Eng); Harad (H); Kadukai (Tam); Kadukka (Mal); Alato, Heerda, Haritaki (Kan); Karaka (Tel); Hirda (Mar); Hirdo (Guj); Harida (O); Hara (Ben); Silikha (A), Harar (P).

Economic use : Bark for tanning and dyeing, fruits medicinal, timber.

Method of propagation : Seed.

Ziziphus species

Common names : Chinese date, Indian cherry plum (Eng); Ber (H); Ilanthai (Tam); Cherumali (Mal); Bogarai, bore, Ilanji (Kan); Regu (Tel); Bor (Mar); Ber, Bordi (Guj); Ajapriya (S); Boyer (O); Ber (Ben).

Economic use : Fruits edible, fodder, oil from seed useful for industrial purposes, firewood, a good plant for afforestation in dry areas on poor soils and in rocky places.

Method of propagation : Seed, grafting.

10.7 Some Fodder Species

Guinea Grass : Guinea grass is one of the best grass varieties. It can be grown on bena lands, coconut garden, alone the irrigation channels, grasslands etc. Guinea grass contains about 8-10 percent of protein. The main variety are Guinea kanvil - assumes good height and good yielder, good for silage.

G. gutton - can be grown in dry areas

G. riversdala - more leafy, good yielder and can be grown on a variety of soils.

Soil and climate : Grows better in areas receiving more than 110 cm of rainfall. Soil with more acdity should be provided with lime and phosphorus.

Seeding : 1-2 kilos of seeds per an acre. Site raised on a seed bed are suitable for planting/clumps planting is most advantageous. 5000-6000 clumps are needed for one acre. Clumps are spaced at one metre and lines are spaced also at one metre.

Manure : per acre, 2-3 tonnes of manure; 80 kg of nitrogen, 20 kg of phosphorus and 10 kg of Potash mixed with the soil, 10 days before planting. Requirement depends upon the soil, irrigation facility etc.

Planting season : After receiving two or three showers during premonsoon peripd. During the first or decond week of June; can be planted during any season if irrigation facility is adequate.

Irrigation : Area should be irrigated before planting once; soon after planting; and at a regular interval of 10-15 days; after every cutting/ harvest.

Harvest : First cutting can be taken after 90 days of planting; then once in 30-35 days; plants should be cut at the ground level; loosening of soil around the clumps after each cutting is beneficial, to the plants.

Yield : 50-60 tonnes per acre on rainfed conditions; 100-115 tonnes, where the irrigation facility is adequate. An economical yield is obtained for 7-8 years.

An intercrop of cowpea, Centrocema, Calapagonium, Desmodium, Subabul etc. with Ghinea grass will be more advantageous.

Green panic : It contains about 10 percent of protein.

Climate and soil : It grows in a variety of climatic conditions and soils. It grows even in areas with a rainfall of less than 20-24 ins.

Seed rate : 2-3 Kg of seeds per acre and 35,000 sets/ clumps per acre. Spacing - from clump to clump is 30 cm and between two rows is 45 cms.

Manure : 1.5-2 tonnes of FYM manure per acre and 60 kg of N, 10 kg of Phosphorus and 10 kg of Potash per acre before planting.

Planting season : During first or second week of June (soon after one or two showers); in any season, if adequate irrigations is available.

Irrigation : Before planting and soon after planting: at an interval of 15-20 days.

Cutting : First cutting is after 90 days of planting. On an average of 10-12 cuttings in one year.

Yield : 35-40 tonnes per acre in rainfed conditions and about 90 tonnes with irrigation.

This grass can be grown on betta lands, bena, and can replace karada grass.

Rhodes : It gives a good yield with adequate irrigation. It contains about 10-11 percent of protein. It is good fodder for calves.

Climate and soil : It is draught resistant and winter hardy. It grows on a variety of soils, except on clay black cotton soils; grows best on loamy soils.

Seeding rate : 1-2 kg per acre. Planting clumps is more advantageous. 35000-40000 clumps are necessary for one acre.

Planting : Soon after first showers of monsson.

Manure : 200-300 tonnes of FYM manure per acre, and 10 kg of Nitrogen, they are mixed with soil; the soil is ploughed, watered and then planted. Application of Nitrogen is beneficial after each cutting.

Irrigation : During ploughing before planting and once soon after planting. Once in 15-20 days afterwards.

Harvest : First cutting after 90 days of planting and then once in 25-30 days.

Yield : 40-45 tonnes per acre for year in rainfed conditions; and 90 tonnes per acre with adequate irrigation.

Para grass : It is a suitable grass variety for water logged areas; comes up well along drainage channels. Grass persists for a long period - upto 8-10 years, giving a very good yield.

Climate and soil : Grows in varied conditions.

Seeding rate : 35000-40000 sets are required per acre

Manure : 2-3 tonnes of FYM manure for one acre, along with 5-10 kg of Nitrogen - mixed with soil; the field is irrigated. Sets are planted after 15-20 days. Applications of nitrogen after each cutting is beneficial.

Planting : First/second week of June. Sets are planted at 30 cm. spacing and spacing between two rows is 60 cm.

Irrigation : Soon after planting and once in a week then onwards.

Cutting : First cutting is taken after 90 days of planting and then once in 30-40 days.

Yield : 60-70 tonnes per acre per year in rainfed condition and 80-90 tonnes per acre with adequate irrigation.

This grass should be given in the form and green fodder. Not suitable for Silage.

Hybrid Nepier : Heavy yielder. It contains about 8-9 percent of protein. Important varieties are N13-21, BH-18, BH-12 and BH-8.

Climate and Soil : Thrives in varied conditions; does not grow well on high acid soils and water logged areas.

Seeding rate : Sets with roots are most suitable for planting. 4500-6000 sets are required per acre. Sets are placed at one metre spacing in rows.

Manure : 2-4 tonnes of FYM manure; 50 kg of Nitrogen, 40 kg of Phosphorus and 40 kg of Potash are mixed with soil before planting and field is irrigated. Application of 20-30 kg of N is beneficial after each cutting.

Planting : Soon after first two or three showers at the beginning of monsoon : can be planted in all seasons, if adequate irrigation is available.

Irrigation : During the preparation of the field for planting and soon after planting. After planting, once in 10-15 days; and every time when manure-fertilizers are applied after each cutting.

Cutting : First cutting is after 90 days of planting; then onwards once in 30-40 days. It should be cut at the ground level.

Tender grass can be harmful to the cattle.

Yield : 70-80 tonnes per year in rainfed conditions and 120 tonnes can be taken with good cultivation methods.

If the cattle are fed only with this grass, the cattle develop calcium deficiency. It should be mixed with other logaminous fodder.

Grasses like -- Sudan, Glycine, Setaria etc.

Apart from raising fodder with grasses, various other crops like maize, leguminous creepers, such as calapogonium, centracema, puereria and Subabul can be cultivated along with grasses or separately on marginal lands, bunds etc., which would provide a balanced green fodder-diet to cattle, throughout the year.

Sources of Seeds

1. Indo-Adstralian Fodder Development Centre, Hessaraghatta, Bangalore 572113.
2. BAIF, Rural Development Institute, KR Extension, P.B. No. 3, Tiptur-572202.
3. Agricultural College, U.A.S., Dharwar
4. Green Fodder Farm, KSF 10, Balekoppa, Siddapur, Uttara Kannada
5. Agricultural Training School, Kumta, Uttara Kannada
6. Red-Dane Project, Hessaraghatta Bangalore; and Sub-centre, Dharwar

[Also various traders in Karnataka, Kerala and Tamilnadu]

10.8 How to Grow Mangroves?

(A.G. Untawale)

1. Introduction

Mangrove is a typical tropical and specialised ecosystem in the saline and brackish water systems. This ecosystem is highly productive and economical which also protects the shoreline from erosion and cyclonic conditions. In India the total area covered by mangroves has been estimated to be about 700,000 ha. (Fig.1). However, this fragile and sensitive ecosystem has been abused, neglected and overexploited in India. The major threats to mangroves are deforestation, reclamation and lately pollution also.

2. Why only mangroves?

There are approximately 45 species which belong to the angiosperms. They have special characters like viviparous germination, pneumatophores, prop of kee roots and salt glands. These trees form a thick forest belt on the deltas along the major estuaries, and fringe the estuarine banks, as well as backwaters. This unique tree resource is used for various purposes like tanin, paper and pulp, firewood, timber, charcoal, alcohol, fodder, and several other by products. The mangrove swamps are rich in the larvae of many economically important fishes, prawns, crabs, and bivalves. They are the most suitable areas for feeding, breeding and nursery grounds of these marine organisms, and hence important for aquaculture purposes.

3. Why mangrove afforestation?

Indian mangroves have been deforested, and reclaimed to such an extent that the mangroves along the west coast are considered as the degraded mangroves. This has not only affected the coastline but also the fisheries to a large extent.

Afforestation of mangrove areas on a large scale is the most urgent need of today, if the coastal environment is to be brought back again to its earlier pristine glory.

In the present note some information is given for undertaking the afforestation programme along the coastline.

4. Where mangroves grow? 10.57

Mangrove trees are found growing luxuriantly in the intertidal regions along the estuaries, backwaters, islands and other protected areas. They generally prefer soft, clay mud for their growth. These species show different salinity tolerance limits.

The expanse of mangrove forest depends on the intertidal expanse, substratum and salinity of soil and water. The inundation of the mangrove region is also one of the important factors.

5. Which mangrove species?

Out of 45 mangrove species some are true mangrove species while others are considered as 'associated' flora. The most dominant mangrove species found along the east and west coasts of India are listed below:

1. Rhizophora mucronata
2. Rhizophora spiculata
3. Bruguiera gymnorhiza
4. Bruguiera parviflora
5. Sonneratia alba
6. Sonneratia caseolaris
7. Ceriops tagal
8. Heretiera littoralis
9. Xylocarpus granatum
10. Xylocarpus molluscensis
11. Excoecaria agallocha
12. Lumnitzera racemosa
13. Avicennia officinalis
14. Avicennia marina

There are several other species which are also useful for different purposes. However, the species mentioned above are available easily and their seedlings (propagules) or seeds are also available in considerably quantity.

6. How to identify species?

For this purpose the leaf shape and details of propagules (seedlings) of some mangrove spp. are shown in Fig. 2. For detailed information other literature has been indicated at the end.

7. When seeds and seedlings are to be collected?

Mangrove seeds (fruits and seedlings) are always available in small quantity throughout the year. The main fruiting or seedling season, however, starts from June to September, when plenty of seedlings of all the Rhizophoraceae, Avicennia and others can be collected.

8. Which seedlings?

Only mature seedlings of these mangrove species should be collected for afforestation or nursery purposes. The seedlings of Rhizophoraceae trees have a podlike structure with tapering end (as shown in the figure) of varying sizes and with typical morphological characters. Avicennia fruits are triangular in shape while Sonneratia is globular.

Fruits or seedlings which are not fully matured or ripe may not grow further resulting into high mortality rate.

9. How to store?

Different mangrove propagules or seedlings have varying sensitivity for the period of storing.
Species of Rhizophorn, Avicennia, Bruguiera can be stored for 6-7 days in brackishwater. However, seedlings of Ceriops and Kandelia were observed to be very sensitive. Such seedlings are to be transplated in the natural swamps or in polythene bags in the nursery immediately, where sufficient moisture or tidal water is available. Sonneratia fruits can be stored for a longer period.

It is however, always advisable to store these seedlings partially immersed (pointed end in water) in seawater.

10. How to plant?

There are two ways of planting the mangrove seedlings.

a) Direct planting in the swamp

b) Raising seedlings in the nursery

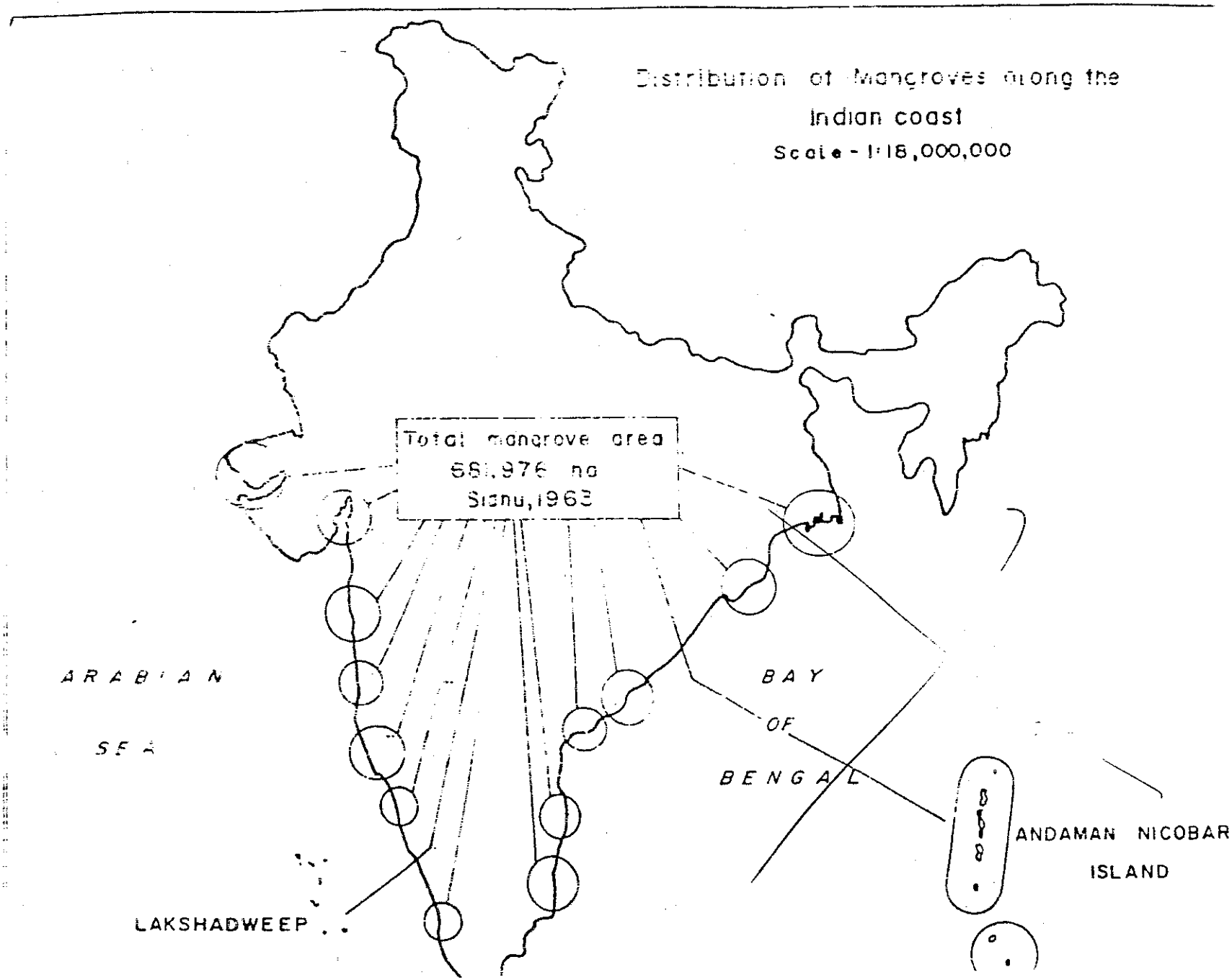

Distribution of Mangroves along the
Indian coast
Scale - 1:18,000,000
Total mangrove area
681,976 ha
Sidhu, 1963
ARABIAN
SEA
BAY
OF
BENGAL
ANDAMAN NICOBAR
ISLAND
LAKSHADWEEP

Fig. 2

Identification of Mangroves with the help of leaves and seedlings

AA'	Rhizophora mucronata
BB'	Rhizophora apiculata
CC'	Bruguiera gymnorhiza
DD'	Bruguiera parviflora
EE'	Kandelia candel
FF'	Ceriops tagal
GG'	Sonneratia alba
HH'	Avicennia officinalis

a) Direct planting: When seedlings are collected, check those for any insect borer or other infections and injuries. Discard such seedlings. Select only healthy, non-infected and fully matured seedlings.

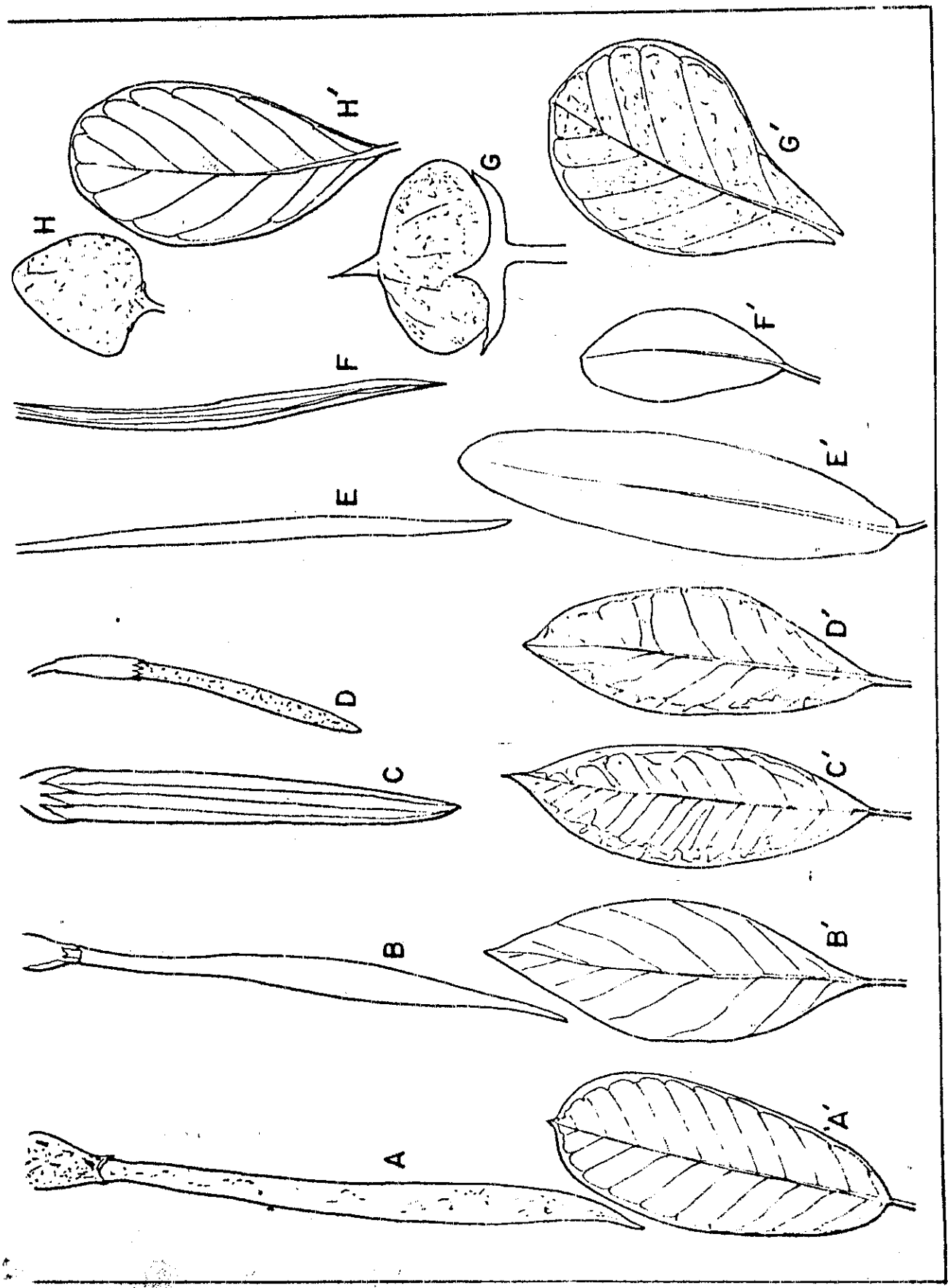
Any intertidal area (between the high tide and low tide) where mangroves are absent and the substratum is of soft clay or mud andis inundated by regular tidal waters everyday, are suitable for direct mangrove planting. Select the sites where tidal expanse is more. Along the Gujarat coast and West Bengal, where intertidal expanse is very large with highest tidal amplitude of 6 to 8 m the upper limit of 1m tidal water level has to be selected.

Planning: Before starting actual selected planting, it is essential to make a tentative plan of the operation. How much area is available and which species to be planted where.

Make suitable plots depending on the availability of the area. There should be a distance of about 10 m in between two plots. In case of fringing mangroves, where intertidal expanse is narrow, parallel to the shoreline. In larger areas plots may be either rectangular or square with a gap in between two plots (Fig 3).

Planting of different species has also to be decided. Plantation of seedlings may be undertaken according to the length of the propagules. Rhizophora mucronata or Rhizophora apiculata whose seedlings are the largest should always be planted towards the waterfront, this can be followed by Kandelia, Ceriops, Bruguiera, Avicennia, Lumnitzera etc. Species with smaller seeds like Sonneratia will come in the landward side of the intertidal expanse, followed by species of grasses and sedges (Fig.4).

Direct planting method has to be used in open areas. The selected propagules or seedlings are transported to the site and planted. Care has to be taken that the pointed end of Rhizophora, Ceriops, Bruguiera, Kandelia seedlings should always be penetrated into the mud (Fig.5), and the other blunt end, which is a shoot portion, should always be 6-8 inches above the soil level. Avicennia fruits are to be pressed gently into the soil surface.



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Penetration or insertion of seedlings into the substratum depends on the local current speed. If the current is very strong, the seedlings should be inserted deeper into the mud, than in the areas where current is feeble.

b) Nursery technique: This method is useful where the mangrove species are not available in plenty. This also has many advantages, like selected species are available in large quantities.

11. Spacing between plants

This is another important factor. Spacing differs according to the purpose for which the plants are grown, and also depends on the mangrove species grown.

However, for the plants suggested above the spacing between two plants may be about 1.3 m to 1.5 m.

Aftercare:

Once the plantation is over then there is not much to be done. Only these plantations are to be protected from the grazing cattle, goats, sheeps and camels.

Periodical checking is helpful in finding out whether there is any need for replacement. But this is very minor.

There is no need of any insecticide, pesticide, fertilizer, or anything, but only protection. Plants will grow on their own.

12. Where to plant?

The mangrove nursery may be located near the estuary or sea where seawater or estuarine water is available. The nursery may be on the open ground or in the low lying protected areas where seawater reaches.

The collected, and selected seedlings are inserted in the polythene bags (4" x 10" size) filled with mangrove soil. If the nursery is on the raised ground then the perforations in the bags are not needed, but the nurseries in the low lying areas need the perforations in the polythene bags.

The seedlings thus grown, in different sizes of plots, need watering everyday. However, the low lying areas get natural tidal waters twice every day.

These seedlings may be allowed to grow upto the period of 6 months to 1 year and then depending on the requirement of species of the region these can be transfered to the site in a boat or cart.

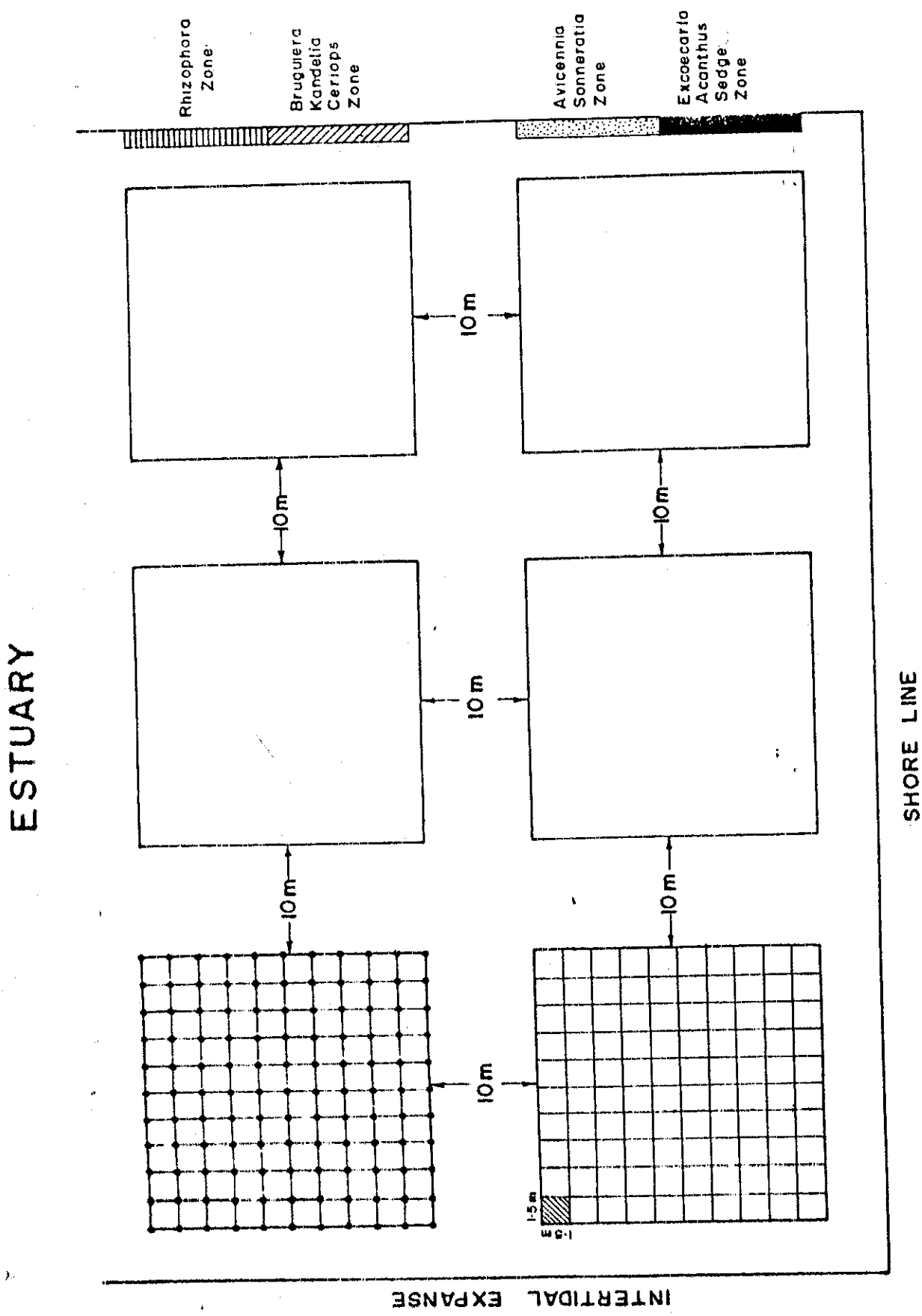
The transplantation technique may be same as indicated for direct planting. Only care should be taken to cut open the polythene bags at the base. Spacing may be the same, depending on the purpose.

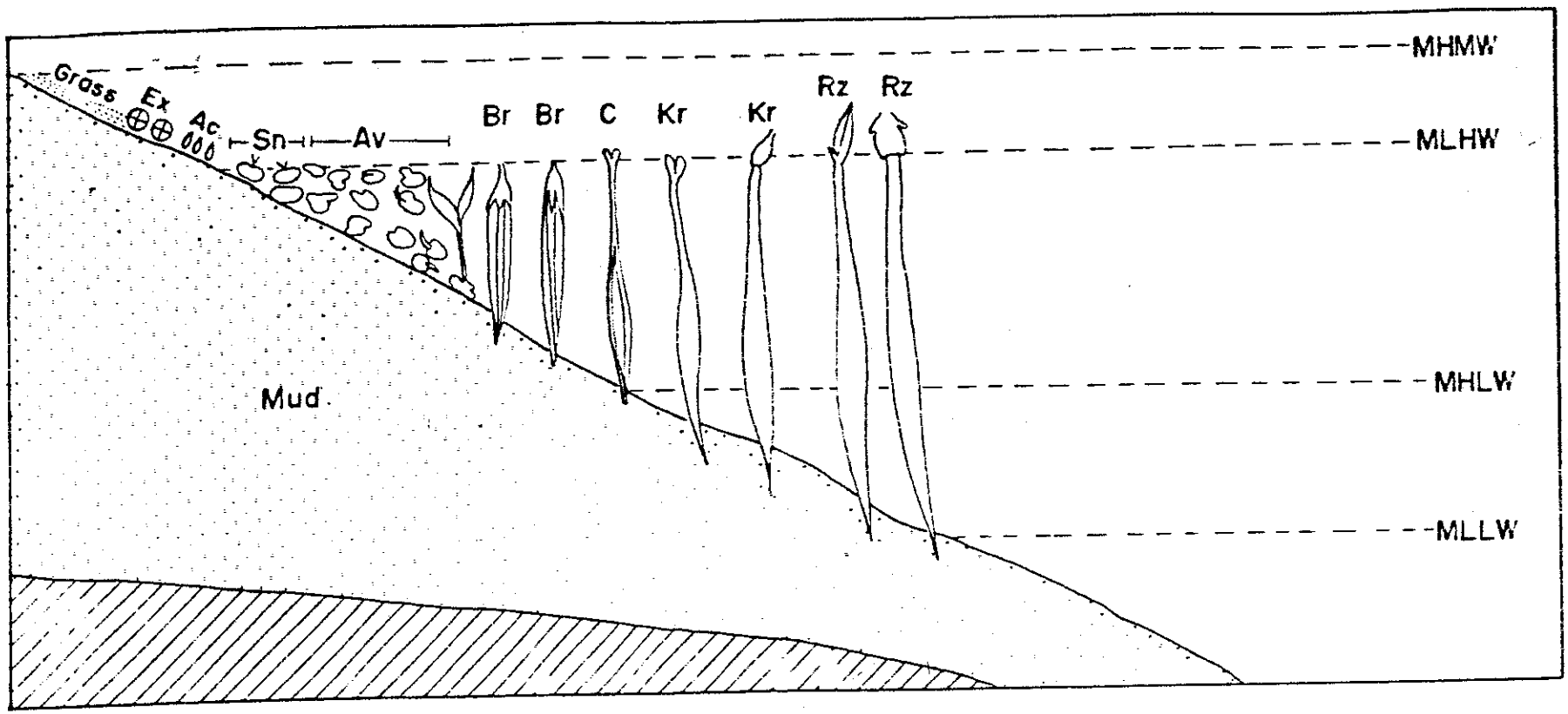
13. Any poisonous plants?

There are no poisonous plants in mangroves. However, while handling Excoecaria agallocha care should be taken not to touch the milky juicy to the eyes. This is harmful and sometimes leads to blindness.

4) 14) What is the survival rate?

If due care is taken in selecting the seedlings used for plantation, then the survival rate is very high (about 90 to 95%). However, the mortality may be because of very strong current or heavy toxic pollutants from the industries. Therefore, it will be advisable to avoid such polluted areas. Sewage pollution or low level nontoxic pollutants may not


Rhizophora Zone
Bruguiera Kandelia Ceriops Zone
Avicennia Sonneratia Zone
Excoecaria Acanthus Sedge Zone
ESTUARY
SHORE LINE
INTERTIDAL EXPANSE
10 m
10 m
10 m
10 m
10 m
10 m
1.5 m
1.5 m


MHMW
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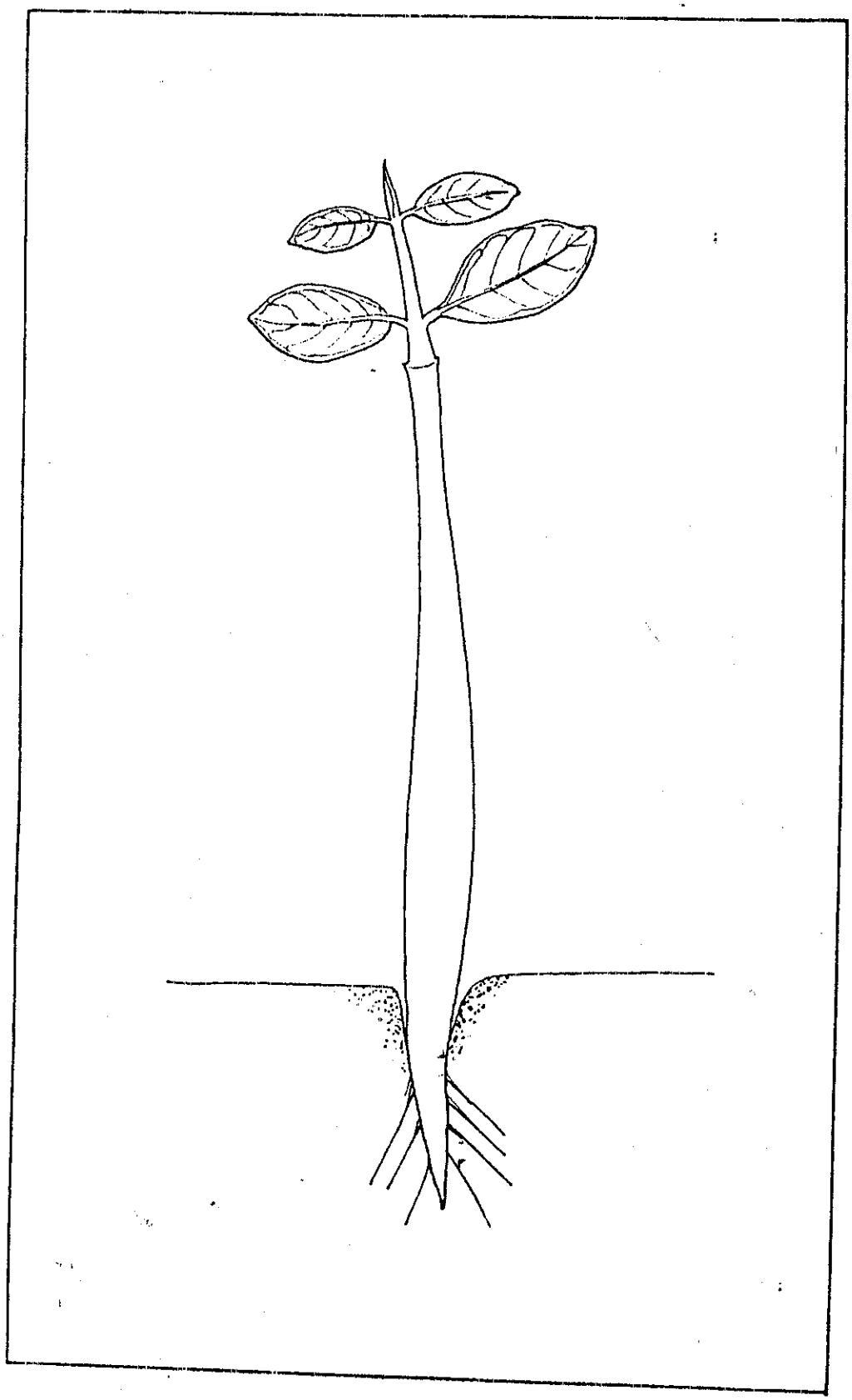

have harmful effect on mangrove plants. On the other hand it has been found that mangrove trees can reduce the pollution by absorbing certain chemicals.

15) Literature for further reading

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10.9 Tree Species

1.	Name of the Species	: Ailanthees malabarica Halmaddi dhupa
2.	Growth Habit	: Large, evergreen tree
3.	Distribution	: Western peninsula
4.	Serial Status	: Shade bearer
5.	Seed Collection season	: April - May
6.	Season of sowing in Nursery	: May - June
7.	Recommended site for planting:	
	a) Physical parameters	: All soils; overhead shades
8.	Growth rate	: Fast
9.	Utilisation	: In soft wood industries; resin collected from stem-used as funigate
1.	Name of the Species	: Albizia lebbeck Bage, Sirsal
2.	Growth Habit	: Moderate sized, deciduous tree
3.	Distribution	: Indigenous to India; in sub-Himalayan region and Indian peninsula
4.	Seral Status	: Strong light demander
5.	Seed collection season	: February
6.	Seed weight	: 8,000 to 13,000 seeds per kg.
7.	Viability	: High
8.	Recommended storage	: Sealed tins
9.	Season of sowing in Nursery	: March - April
10.	Recommended site for planting	:
	a) Physical parameters	: Open area, laterite soils
	b) Susceptibility to fire, grazing	: Grazed upon by animals
11.	Growth rate	: Slow initially; faster after establishment
12.	Utilization	: Wood is durable; used for furnitures, boat building. Leaves are used as fodder

1.	Name of the Species	: Anacardium occidentale Geru, Godambi
2.	Growth Habit	: Moderate sized, evergreen tree
3.	Distribution	: Tropical evergreen forests
4.	Seral Status	: Light demander
5.	Seed collection season	: April - May
6.	Seed weight	: 145-165 per Kilogram
7.	Recommended storage	: Sealed tins
8.	Season of sowing in Nursery	: May - June
9.	Recommended site for planting:	
	a) Physical parameters	: All soils
	b) Social parameters	: School forests, farms
10.	Growth rate	:Moderate
11.	Utilisation	: Apple and kernels edible. Oil is extracted from kernels; "Cardo Oil" extracted from pericarp of seeds; wood is need in boats and as fuel

1.	Name of the Species	: Artocarpus hirsuta
2.	Growth Habit	: Tall, evergreen tree
3.	Distribution	: Evergreen forests of Western Ghats
4.	Seral Status	: Shade bearer; Thrives best in fair amount of light
5.	Seed collection season	: May - June
6.	Seed weight	: 1400 seeds per kilogram
7.	Viability	: Low
8.	Season of sowing in Nursery	: May - June
9.	Recommended Nursery Practice	: In containers
10.	Size and Age at transplanting into plantation	: 50-60 cms in height
11.	Recommended site for planting	:
	a) Physical parameters	: Laterite soils; high rainfall areas
	b) Susceptibility to fire, grazing	: Sensitive to fire; browsed upon by cattle and other animals
12.	Growth rate	: Slow- but rapid after establishment
13.	Utilization	: Wood is valuable; house construction, furnitures, ship building etc.

1. Name of the Species : Artocarpus integrifolia
   Halasu
2. Growth Habit : Large, evergreen tree
3. Distribution : In Western peninsula
4. Seral Status : Light demander; shade bearer
5. Seed collection season : May - June
6. Viability : Low
7. Season of sowing in Nursery : June
8. Recommended site for planting:
   a) Social parameters : School forests
9. Growth rate : Moderate
10. Utilisation : Fruits are edible. Wood is durable, excellent timber; used in furnitures

1. Name of the species : Calophyllum inophyllum
   Sura honne
2. Growth Habit : Moderate sized, evergreen tree
3. Distribution : In India- on West Coast and east coast
4. Seral Status : Light demander; withstands xerophitic conditions
5. Seed collection season : March
6. Seed weight : 212 seeds per kilogram
7. Viability : Low
8. Recommended Storage : Cannot be stored for a long period
9. Season of sowing in Nursery : April
10. Recommended Nursery Practice : Better raised in containers
11. Recommended site for planting:
    a) Physical parameters : Fertile; soils; along rivers/ coastal forests high rainfall areas
12. Growth rate : Moderate
13. Utilisation : For beams, furnitures, railway carriages. Seed kernels yield oil used in burning.

1. Name of the Species : Calophyllum tomentosum Bobbi
2. Growth Habit : Tall, evergreen tree
3. Distribution : In semievergreen and evergreen forests of Western Ghats
4. Seral Status : Shade bearer
5. Seed collection season : April
6. Seed weight : 152 nuts per Kilogram/141-183 seeds per Kg
7. Viability : High
8. Recommended Storage : In gunny bags
9. Season of sowing in Nursery : May - June
10. Recommended Nursery Practice : Raised in containers
11. Recommended site for planting :
    a) Physical parameters : Sandy loam, moist & fertile soil;
    b) Social parameters : Reserve forests
    c) Susceptibility to fire, grazing: Sensitive to fire
12. Growth rate : Moderate
13. Utilisation : Timber is strong; used in construction work, boat and ship building. Seed kernels yield oil used for burning

1. Name of the Species : Calophyllum wightianum Hole Honne
2. Growth Habit : Tall, evergreen tree
3. Distribution : Evergreen and semievergreen forests of Western Ghats; along the rivers
4. Seral Status : Shade bearer; thrives in open also
5. Seed collection season : March
6. Viability : Low
7. Season of sowing in Nursery : May - June
8. Recommended Nursery Practice : Raised in containers

9. Recommended site for planting:

a) Physical parameters : Under shade on hill slopes; on laterite soils near streams

b) Social parameters : Reserve forests .

c) Susceptibility to fire, grazing : Sensitive to fire

10. Growth rate : Moderate

11. Utilisation : It is strong constructional timber seeds yield oil used in burning

1. Name of the species : Casuarina equisetifolia Gatemara

2. Growth Habit : Large, evergreen tree

3. Distribution : Cultivated in greater parts of India

4. Seral status : Strong light demander

5. Seed collection season : June and December

6. Viability : low

7. Season of sowing in Nursery : June

8. Recommended Nursery Practice : Beds as well as in containers

9. Recommended site for Planting

a) Physical parameters : All soils; open area

b) Susceptibility to fire, grazing: Sensitive to fire; and browsed upon by animals.

10. Growth Rate : Fast

11. Utilisation : Wood yields very good fuelwood. Poles are used in house-construction. Bark is used for tanning

1.	Name of the Species	: Dalbergia latifolia Bete
2.	Growth Habit	: Large, deciduous tree
3.	Distribution	: Widely distributed in India. In Karnataka, is found most extensively
4.	Seral Status	: Shade bearer
5.	Seed collection season	: March - April
6.	Seed Weight	: 18,500-40,000 seeds per Kg
7.	Viability	: One year
8.	Recommended Storage	: Sealed tins
9.	Season of sowing in Nursery	: April - May
10.	Recommended Nursery Practice	: Better raised in polybags

11. Recommended site for planting:

a) Physical parameters : All soils; thrives well in moist conditions

b) Susceptibility to fire, grazing: Plants are grazed upon by animals, cattle

12.	Growth Rate	: Moderate
13.	Utilisation	: Durable wood; used in furnitures, carving, agricultural implements. Leaves serve as fodder
1.	Name of the species	: Dillenia pentagyna Kanagalu
2.	Growth Habit	: Moderate sized, deciduous tree
3.	Distribution	: Widely distributed in Central, Western and South India
4.	Seral Status	: Light demander
5.	Seed collection season	: May
6.	Seed weight	: 37,400-51,200 seeds per Kg
7.	Viability	: Low

8. Season of sowing in Nursery : May - June

9. Recommended site for planting

a) Physical parameters : laterite soil, moderate to high rainfall area;

b) Social parameters : Betta, minor forests

c) Susceptibility to fire, grazing: Resistant to fire: browsed upon by animals

10. Growth rate : Slow

11. Utilisation : Wood is not durable. Fruits are eaten by animals. Leaves serve as fodder and good manure. Wood is used in packing cases; and as firewood.

1. Name of the species : Gmelina arborea
Shivane

2. Growth Habit : Moderate sized, deciduous tree

3. Distribution : Mixed forests of moist regions

4. Seral status : Light demander

5. Seed collection season : May

6. Seed weight : 2500-2600 dry seeds per Kg

7. Season of sowing in Nursery : May - June

8. Recommended Nursery Practice : Better raised in containers

9. Recommended site for planting

a) Physical parameters : All soils

b) Susceptibility to fire, grazing: Browsed upon by the cattle

10. Growth rate : Good

11. Utilisation : Strong and light timber- used in furnitures, planking etc. Leaves are used as fodder. Fruits are eaten by tribes.

1. Name of the species	: Hydnocarpus wightiana Toratti
2. Growth Habit	: Moderate sized; evergreen tree
3. Distribution	: Tropical forests along Western Ghats
4. Seral Status	: Shade tolesant
5. Seed collection season	: May - June
6. Seed weight	: 700-900 seeds per Kg
7. Recommended storage	: Sealed cans/plastic bags
8. Season of sowing in Nursery	: September
9. Recommended Nursery Practice	: Raised in containers
10. Recommended site for planting	
a) Physical parameters	: Along streams; evergreen forests; flat terrain
b) Social parameters	: Minor forests, Reserve forests
11. Utilisation	: Building purpses; good fire-wood. Seeds yield valuable medicinal oil.

1. Name of the species	: Kydia calycina Bende or Nayi bende
2. Growth Habit	: Moderate sized, deciduous tree
3. Distribution	: Major part of India in plains; in mixed deciduous forests
4. Seral status	: Strong light demander; tole-rates shade. Drought resistant
5. Seed collection season	: December to February
6. Seed weight	: 37,000 per Kg.
7. Viability	: One year
8. Recommended Storage	: In gunny bags
9. Season of sowing in Nursery	: May

10. Recommended Nursery Practice : Better raised in poly bags

11. Size and Age at transplanting into plantation: One year old seedlings

12. Recommended site for planting

a) Physical parameters : High rainfall to dry areas

b) Susceptibility to fire, grazing: Grazed upon by cattle, and wild animals

13. Growth rate : Fast

14. Utilisation : Soft wood industries-news print, matches, pencil industries, packing cases.

1. Name of the species : Lagerstraemia lanceolata

2. Growth Habit : Large, deciduous tree

3. Distribution : On western peninsula

4. Seral status : Light demander; shade bearer

5. Seed collection season : February

6. Seed weight : 6,600 seeds per Kg

7. Season of sowing in Nursery : April-May

8. Growth rate : Moderate

9. Utilisation : Used in house construction, boxes, furnitures.

1. Name of the species : Leucaena leucocephala Subebal

2. Growth Habit : Medium sized, evergreen tree

3. Distribution : Introduced all over India

4. Seral Status : Light demander

1. Name of the species : Mangifera indica

2. Growth Habit : Large, evergreen tree

3. Distribution : Throughout the country

4. Seral status : Shade bearer

5. Seed collection season : April-June

6. Seed weight : 55 seeds per Kg

7. Viability : Low

8. Season of sowing in Nursery : June

9. Recommended site for planting

a) Social parameters : School forests, farms

10. Growth rate : Moderate

11. Utilisation : Leaves are good for leaf manure. Wood is used for planking, boat building, packing cases etc.

1. Name of the species : Mesua ferrea
Naga Sampige

2. Growth Habit : Medium to large sized evergreen tree

3. Distribution : In evergreen and semievergreen forests of India

4. Seral Status : Pronounced shade bearer especially when it is young

5. Seed collection season : May - June

6. Viability : Low

7. Dormancy : Due to hard seed covering; seeds soaked in cold water germinate better

8. Season of sowing in Nursery : June

9. Recommended Nursery Practice : Seedlings are better raised in containers

10. Size and age at transplanting into plantation : One year old seedlings with 2' height

11. Recommended site for planting

a) Physical parameters : Hilly ground, flat terrain, well drained soils.

b) Social parameters: Reserve forests

c) Susceptibility to fire, grazing: Sensitive to fire; damaged by wild animals.

12. Growth rate : Moderately fast

13. Utilisation : For railway sleepers, bridges; in house construction, cake of seeds is used as manure

1. Name of the Species : Michelia champaca Sampige

2. Growth Habit : Tall, evergreen tree

3. Distribution : Indigenous to most of the forests in India; widespread in Tropical Asia

4. Seral Status : Light demander, shade tolerant

5. Seed Collection season : August - September

6. Viability : Low

7. Dormancy : No

8. Recommended storage : Seeds do not stand storage

9. Season of sowing in Nursery : August - September-as soon as the seeds are collected

10. Recommended Nursery Practice : Seedlings are better raised in polybags/earthern pots

11. Size and Age at transplanting into plantation : 2' tall and one year old seedlings thrive better

12. Recommended site for planting

a) Physical parameters : Moist, well drained, fertile soils; suitable for under planting moderate to high rain fall area

b) Social parameters : Along roads, school forests; 'Devara Kadu'

c) Susceptibility to fire, grazing: Sensitive to fire; subjected to grazing

13. Growth rate : Fast growing

14. Utilisation : Fragrant flow rs yield ch mpaca oil. Good timber for light furnitures; used in plywood industries, packing cases

1. Name of the species : Polyalthia fragrans
Mara Gouri

2. Growth Habit : Tall, evergreen tree

3. Distribution : Evergreen forests of Western Ghats

4. Seral Status : Shade bearer

5. Seed collection season : May - June

6. Viability : Low

7. Season of sowing in Nursery : June - July

8. Recommended site for planting

a) Physical parameters: under shade; in high rainfall areas

b) Susceptibility to fire, grazing: Sensitive to fire

9. Growth rate : Slow

10. Utilisation : In plywood industries, matches, packing cases

1. Name of the species : Pongamia glabra
Honge or Jorangalu

2. Growth Habit : Moderate sized; nearly evergreen tree

3. Distribution : Throughout greater part of India

4. Seral status : Shade bearer; drought resistant

5. Seed collection season : April - May

6. Seed weight : 800 - 1500 seeds per Kg

7. Viability : Six to Nine months

8. Season of sowing in Nursery : May - June

4. Seral status : Shade bearer

5. Seed collection season : April-June

6. Seed weight : 55 seeds per Kg

7. Viability : Low

8. Season of sowing in Nursery : June

9. Recommended site for planting

a) Social parameters : School forests, farms

10. Growth rate : Moderate

11. Utilisation : Leaves are good for leaf manure. Wood is used for planking, boat building, packing cases etc.

1. Name of the species : Mesua ferrea
Nāgā Sampige

2. Growth Habit : Medium to large sized evergreen tree

3. Distribution : In evergreen and semievergreen forests of India

4. Seral Status : Pronounced shade bearer especially when it is young

5. Seed collection season : May - June

6. Viability : Low

7. Dormancy : Due to hard seed covering; seeds soaked in cold water germinate better

8. Season of sowing in Nursery : June

9. Recommended Nursery Practice : Seedlings are better raised in containers

10. Size and age at transplanting into plantation : One year old seedlings with 2' height

11. Recommended site for planting

a) Physical parameters : Hilly ground, flat terrain, well drained soils.

9. Recommended site for planting

a) Physical parameters : Laterite soils; high rainfall to Dry areas; open areas/under shade

10. Utilisation : Leaves serve as fodder and good manure. Wood is durable and good firewood

1. Name of the species : Pterocarpus marsupium Honne

2. Growth Habit : Large, deciduous tree

3. Distribution : Deciduous forests in Indian peninsula

4. Seral status : Light demander

5. Seed collection season : April - May

6. Seed weight : 1,600-1,980 seeds per Kg

7. Season of sowing in Nursery : April - May

8. Recommended site for planting

a) Susceptibility to fire, grazing: brawsed upon by cattle, goats, etc.

9. Growth rate : Moderate

10. Utilisation : Leaves serve as fodder; Wood is durable-used for many purposes; tree contains-gum resin 'kino' of commerce

1. Name of the species : Robinia pseudo-acacia

2. Distribution : It is introduced in India

3. Seral status : It is a strong light demander

4. Seed collection season : August - September

5. Season of sowing in Nursery : November - December

1. Name of the species : Swietenia mahogany
   Mahogany
2. Growth Habit : Large, evergreen tree
3. Distribution : Introduced in moist deciduous/ evergreen forests in India
4. Seral status : Light demander
5. Seed collection season : February - March
6. Season of sowing in Nursery : April - May
7. Growth rate : Moderate
8. Utilisation : Wood is used in cabinet making and constructional work

1. Name of the species : Syzygium cumini
   Nerale
2. Growth Habit : Medium to large sized, evergreen tree
3. Distribution : Throughout India
4. Seral status : Shade bearer
5. Seed collection season : June
6. Seed weight : 1,100 - 1,300 seeds per Kg
7. Viability : Low
8. Recommended site for planting
   a) Physical parameters : all soils
   b) Social parameters : School forests, farms
   c) Susceptibility to fire, grazing: Sensitive to fire and browsed upon by animals
9. Growth rate : Moderate
10. Utilisation : Wood is good; yields good timber. Fruits are edible

1. Name of the species : Tamarindus indica
2. Growth Habit : Evergreen tree
3. Distribution : Throughout India, except in Himalayan region
4. Seral status : Light demander
5. Seed collection season : March - April
6. Seed weight : 880 - 900 seeds per Kg
7. Recommended storage : Sealed tins
8. Season of sowing in Nursery : March - April
9. Recommended site for planting
   a) Physical parameters : In plains; all soils
   b) Social parameters : School forest, farm
10. Growth rate : Moderate
11. Utilisation : Timber is valuable; Fruits are edible; tender leaves are used as vegetables

1. Name of the species : Terminalia bellirica
   Tare
2. Growth Habit : Large, deciduous tree
3. Distribution : In deciduous forests in greater parts of India
4. Seral status : Light demander
5. Seed collection season : December - February
6. Viability : One year
7. Recommended storage : In sealed tins
8. Season of sowing in Nursery : March - April
9. Recommended site for planting
   a) Physical parameters : All soils

10.	Growth rate	: Moderate
11.	Utilisation	: Fruits are edible; oil from seeds used in tanning; wood is used in canoe building, packing cases etc.
1.	Name of the species	: Terminalia paniculata Honalu
2.	Growth Habit	: Large, deciduous tree
3.	Distribution	: In the forests of west coast from Bombay, southwards
4.	Seral status	: Light demanders; withstand shade
5.	Seed collection season	: February - March
6.	Season for sowing in Nursery	: March - April
7.	Growth rate	: Moderate
8.	Utilisation	: Leaves serve good manure. Wood is durable - used in building construction
1.	Name of the species	: Terminalia tomentosa Matti
2.	Growth Habit	: Large deciduous tree
3.	Distribution	: Widely distributed except in arid regions
4.	Seral status	: Light demander
5.	Seed collection season	: April - May
6.	Seed weight	: 400 - 700 fruits per Kg
7.	Viability	: One year
8.	Season of sowing in Nursery	: April - May
9.	Recommended Nursery Practice	: Better raised in container

10. Size and age at transplanting into plantation: One year old seedlings

11. Recommended site for planting

a) Physical parameters : Variety of soils; good rainfall

12. Growth rate : Moderate

13. Utilisation : Valuable timber. Leaves serve as very good manure

1. Name of the species : Jhespes populnea
Bugari, Arcasi

2. Growth Habit : Ever green tree; cultivated as an avenue tree

3. Distribution : Common in coastal tracts in India

4. Seral status : Prefers light

5. Seed collection season : April - May

6. Seed weight : 35 for one gram

7. Season of sowing in Nursery : June

8. Recommended Nursery Practice : Raised in containers

9. Recommended site for planting

a) Physical parameters : Along roads, sandy and rocky coasts

b) Social parameters : Avenue planting; minor forest, betta

10. Growth rate : Fast growing

11. Utilisation : For agricultural implements- wheels, shafts of carts; boat building, bark yields tan and dye; leaves serve as fodder for goats.

1. Name of the species : Vateria indica
Sal dhupa

2. Growth Habit : Large, evergreen tree

3.	Distribution	: It is distributed in south western India
4.	Seral status	: Shade bearer
5.	Seed collection season	: May - June - July
6.	Seed weight	: 50-70 seeds per Kg
7.	Viability	: Low
8.	Recommended storage	: In gunny bags for one month
9.	Season of sowing in Nursery	: June - July
10.	Recommended Nursery practice	: Better raised in container

11. Recommended site for planting

a) Physical parameters : All soils

b) Susceptibility to fire, grazing: Sensitive to fire

12.	Growth rate	: Moderate
13.	Utilisation	: Trees are planted as shade trees. Resin from stem is used as incense in paints/varnishes. Oil extracted from seeds is used in soaps and candles.

Table - 10.1 : Calendar of revegetation operations

Important components are development of nursery and plantations

Nursery development:- The operations, carried out on a nursery are

1. fencing/trenching - depends upon the size of the nursery
2. Levelling or preparation of ground
3. Layout
4. Laying out beds
5. Soil preparation/filling up polybags
6. Sowing of seeds
7. Watering
8. Weeding
9. Transplanting
10. Shading
11. Shifting
12. Conditioning the plants

Plantation:

1. fencing/trenching
2. Site preparation - levelling
3. digging pits
4. filling up the pits/fertilizer
5. planting ; 6. soil work;
7. Irrigation ; 8. Fire belt;
9. Beating up ; 10. soil work

Table - 10.2 : Calendar of Operations on the Nursery

Sl. No.	Months	Work on the nursery	Collection of seeds	Sowing
(1)	(2)	(3)	(4)	(5)
1.	September	Fenching/trenching, site preparation; Layout of beds; procurement of ingredients	Stereospermum sp. hadargith	
2.	October	Procuring ingredients (contd.) Filling up of bags, sowing seeds		Sowing of species of plants which grow slow from precious years collection Stereosperm sp.
3.	November	Sowing of seeds (contd.) watering the sown beds/bags. Weeding on beds/bags	Terminalia chebula	Tichebula - Planting on nursery beds the shoot cuttings of bamboo species
4.	December	Sowing of seeds (contd.) watering, weeding	Spondias occuminata phyllanther emblica Mimusops clangi Semicarpus anacardium	Sowing of freshly collected speeds. Mimusope sp.
5.	January	Sowing, watering, weeding, seeding, transplanting	Mimusops clangi, Sterculia guttata Phyllanthus sp., Disoxylum malabarica. Disophyras siluetica, Myristica sp., Asatonia scholaris, Entada scandus	Sowing fall seeds collected fresh

(1)	(2)	(3)	(4)	(5)
6.	February	Sowing of seeds; transplanging, shading, watering, weeding, shifting	A scholaris; Entada sp., Sterculia sp., Adina cardifolia; Terminalia bellinica, Lagerstraemia lanuolate; Albizzia spp.	Sowing of subabul; Acacia sp.
7.	March	Sowing of seeds, transplanting, shading watering, weeding, shifting	Pongamia glabra; caryota urins; Buchanania lanzan; Anogeissus sp., Gmelina arborea; Xylia xylocarpa; Machillus maerantha; Terminalia paniculata, Dalbergie sp., Diosphysos montana, Calophyllum spp., Strychnos sp.,	
8.	April	Transplanting, shifting watering, weeding, spraying insecticides (if necessary)	Lophopetalum sp; Strychnos nuxvonica; Pterocarpus marsupium; T.tomentosa; Eugenia sp., A.lakoveha, Acacia carcinna; Ziziphus sp., Dillenia pentagyna; Algeodaphne sp., Shorea sp.	
9.	May	Watering, weeding, conditioning the seedlings for planting (removing slowly the shade; control of watering etc.), shifting; transport of seedlings to planting area	Careya arborea; Bassia latifolia; A.hissuta; Macarange peltata, Hyduocarpus wightiana, Shorea faluna, Hopea widetiana, Eugunia spp., Aporasa lindleyama; Vateria indiaa; Mesua ferrea	
10.	June	Transport of seedlings:, cleaning:, weeding; Laying out beds; procuring ingredients, filling the bags	Syzygium cumini, Micholio-champaca, Mesua ferria	Sowing of syzygium cumini; M.champaca, M.ferrea/ and also others

(1)	(2)	(3)	(4)	(5)
11.	July	Clearing, weeding, filling the bags, sowing		
12.	August	-do- Maintenance work--drainage, fencing/trenching;		

Table - 10.3

I. NURSERY

Expenditure for raising 2,500 seedlings in poly bags. Land area required in this case is 25 square metres

Nature of work	Materials	Cost in Rs.		Labour requirement (Man days required)	Cost in Rs.	Total
1.1 Site preparation (levelling)				5.0	75-00	75=00
1.2 Fencing						
A. By using barbed wire and stone pillars	Stone Wire	66-00 176-00	242-00	2.0	30-00	272=00
B. Trenching				5.0	75-00	75-00
1.3 Ingredients	Soil) Sand)	60-00		2.0	30-00	90-00
	Manure	370-00		2.0	30-00	400-00
1.4 Filling and arranging the bags				7.5	75-00	75-00
1.5 Sowing				2.0	20-00	20-00
1.6 Watering				85-00	850-00	850-00
1.7 Weeding				2.0	20-00	20-00

1.8	Shifting and grading		3.0	30-00	30-00
	Total	672-00	115.5	1235-00	1907-00
	Expenditure with fencing	672-00	110.5	1160-00	1832-00
	Expenditure with trenching	430-00	113.5	1205-00	1635-00

+ The cost of hiring a cart is included.

1. The material cost may vary from place to place
2. Watering here refers to the most common method-using rose cans
3. Cost of seeds and polythene bags is not included

II. PLANTATION

Expenditure for planting 2,500 seedlings in an area of one hectare at an espacement of 2 m x 2 m

2.1	Site preparations						
2.2	Fencing	Stone pillars (200)	1,650-00	5,170-00	20	200-00	5,370-00
		Barbed wire (1600m)	3,520-00				
	Trenching				106	1590-00	1,590-00
2.3	Pitting				84	1260-00	1,260-00
2.4	Transport of seedlings	Lorry hire	600-00		6	90-00	690-00

2.5	Planting		13	130-00	130-00
2.6	Watering		-	-	-
2.7	Soil working		25	250-00	250-00
	Total cost	4,770-00	254	3520-00	9290-00
	With fencing	4,770-00	148	1930-00	7700-00
	With trenching	600-00	234	3320-00	3920-00

1. Expenditure on site preparation is not included as it is subjected to vary according to the conditions of the area
2. Transportation cost is calculated for a 10 km distance from the nursery to the planting site
3. Watering cost is not mentioned.

Table - 10.4 : Calender of operations on plantations

Sl. No.	Months	Work on the plantation
1.	September	Marking the area and the pits; Fencing/ trenching around the planting area; site clearing/preparation
2.	October	Trenching/fencing, digging the pits
3.	November	Digging the pits (contd.)
4.	December	-do-
5.	January	Filling up the pits with soil/digging the pits (contd.), adding fertilizers/ lime
6.	February	-
7.	March	
8.	April	
9.	May 2nd week	Planting (begins if premonsoon showers)
	May 4th week	planting
10.	June	Planting
11.	July	
12.	August	Soil work and weeding
13.	September	
14.	October	Soil work can be continued
15.	November	
16.	December	Irrigation (if possible) Maintenance of fence/trunch
17.	January	Irrigation (contd.)

18.	February	Irrigation (contd.), Fire belt (if needed)
19.	March	Irrigation (contd.), Fire belt (contd.)
20.	April	Irrigation
21.	May	Irrigation
22.	June	Beating up and filling the gaps
23.	July	Beating up
24.	August	Soil work for all the plants (including the precious year's planting)
25.	September	

11. ANIMALS

11.1 Variety of animals

A variety of animals ranging from bees yielding honey, crabs and prawns and fish consumed as food to poultry and livestock provide valuable protein and income to the people. Protecting and augmenting the resource base of this animal production ought to be one of the thrusts of ecodevelopment.

The previous chapter has already mentioned some of the plants which may provide nectar and pollen source for bees. We have also dealt with the need to protect the habitat of freshwater and rackishwater shellfish and fish. Poultry may also be of much utility.

11.2 Goats

Goat is the hardiest of our domesticated mammals and is being kept in increasing numbers on the Western Ghats hand in hand with the degradation of the vegetation. Its browsing is however highly destructive of the vegetation, and there is an urgent need to check the explosion of population of free ranging goats. They would ideally be substituted by the stall fed variety.

11.3 Livestock

As with goats, it is clear that our resources can no longer sustain large numbers of free ranging cattle

and buffaloes. These livestock provides three main services to the farmers: (a) Power to plough the land and to transport goods; (b) Dung to fertilize the fields, and (c) Milk. The explosion in the livestock population going hand in hand with that in human population apparently relates to the simultaneous need for a pair of bullocks by every farmer at the critical times for agricultural operations. This has to be carefully evaluated and a strategy evolved to reduce the number of livestock. Along with a reduction in the number must go on improvement in milk yielding ability of animals through cross breeding, an improvement in the availability of fodder and a switchover to stall feeding at least in the dry season.

To achieve this is particularly difficult in case of small farmers and landless who cannot develop fodder resources on their own and who are unable to take the risk of loss of an expensive cross-breed animal. We must seriously work on developing a proper approach towards solving this difficult problem.

12. BIOLOGICAL DIVERSITY

12.1 Our Conservation Ethic

Conserving our heritage of biological diversity is quite as worthwhile a task as enhancing the level of biological diversity. Many of our traditions have played an important role in conserving biological diversity in spite of population pressure in our ancient land. These traditions include:

(i) Protecting trees of certain species such as Banyan and Peepal. But these magnificient old trees are now vanishing, for instance, as packing cases for mangoes.

(ii) Protecting entire biological communities as sacred groves or sacred ponds, for instance Kan forests of Uttara Kannada. These too are now being destroyed.

(iii) Protecting certain life history stages of animals, for example, breeding colonies of storks and pelicans right in the midst of villages.

These old traditions, necessarily vanishing today, must be revived in the modern context. It is important that we take up serious educational programmes to explain the value of biological diversity, to show that our older traditions had real utility although they were based on beliefs which now appear to be superstitions and unacceptable, and to generate alternative

sets of practices in the modern age to conserve this diversity. There are of course the wild life sanctuaries, tiger reserves and so on. But these are founded in an elitist approach which do not involve the rural population in conservation, but instead pit them against nature reserves. This needs to be changed so that the rural people can again be involved in a conservation effort.

12.2 Conflict with Wild Animals

In many parts of the Western Ghats the wild animals, ranging from blacknaped hare and flying squirrel to the gaur and the Indian elephant cause extensive damage to crops. This is a major impediment in efforts to conserve our wild life. It is therefore necessary to reduce this damage to the maximum extent possible by devising methods such as elephant proof trenches or electric wire fences. We must take up action programmes to implement such protective measures in the field.

13. CONSERVATION OF FUEL : It's Role in Ecodevelopment

M. S. Hegde

13.1 Introduction

Shortages of domestic fuel is largely felt in India during the last decade rather acutely. Suddenly there is a rush of programmes such as aforestation, social forestry, farm forestry, etc. This is because, even today, over 80 percent of domestic fuel is met by biomass viz. wood, agricultural residue, dung cakes etc. Therefore, production of more biomass is considered a priority to meet the fuel demands. Yet another approach to tide over the fuel problem can be to conserve fuel by burning the available fuel more efficiently and also extract more heat for cooking, bath water heating etc. It is this second approach we will address in these set of lectures and demonstrate its role in ecodevelopment.

13.2 Fuel consumption pattern

There exists, several studies on the domestic fuel consumption pattern in villages, towns and cities. The notable one is by the ASTRA group of I.I.Sc. A group of 6 villages in Kunigal taluk of Tumkur district was surveyed by them and showed that about 1.3 kg of fuel is required per person per day and almost all of it goes for cooking. We in the centre for Ecological Sciences, IISc, have studied fuel consumption patterns

in a few villages of Uttara Kannada. Our data on village Unchagi (63 houses, 363 persons) show that 1.29 kg/day/person is needed for cooking and 1.0 Kg/day/person for heating hot water bath. Only one house has a biogass plant. Even this house depends upon wood for heating bath water. Kerosene is also used occasionally in this village mainly to prepare tea at odd times The study at Bhairumbe show that 8 percent of the families have biogas plant. Wood required for bath water heating is still higher, is 1.5 kg/day/person. Thus, in Uttara Kannada, per capita consumption of fuel is higher due to excess fuel needs for bath. Our study also showed that 35 percent of fuel is in the form of cut wood, 50 percent of it is twigs and dry leaves, 15 percent is farm residue. Economically poorer sections (constituting 50 percent of the population) depend entirely on the surrounding forest area for their fuel needs and they collect and do not buy wood. Richer farmers Owning coconut and areca gardens meet their fuel needs to the tune of 30 percent from farm residue and this section buy cut wood.

In villages, apart from this, fuel is needed for making jaggery (once a year operation, wood is still used in Uttara Kannata), perboiling rice, processing areca nut, cardamum, drying cloths in 4-5 months long rainy season . Generally,200 kg of wood is used for making

55-60 Kg of liquid jaggery out of 500 kg of sugarcane. In Uttara Kannada alone, over 30,000 tons of wood is burnt every year for making jaggery.

In towns and cities, the fuel consumption pattern varies from those of villages. In towns such as Sirsi in Uttara Kannada, 10 percent of the families use cooking gas and 7 percent use electricity. About 5 percent of the fuel is kerosene. The rest is wood. In Bangalore, 20-25 percent of people depend on wood, dung cakes etc., the rest is out of cooking gas, electricity and kerosene.

13.3 Strategy for fuel conservation

As is clear from the above discussion that in villages, almost all families use biomass as fuel. In towns, over 80 percent of the people are dependent on the renuable resources of energy giz. biomass. Again, the major consumption of fuel is for cooking (over 50 percent of the total domestic fuel) and the rest is for bath water heating. In Uttara Kannada, bath water heating is very important unlike in the drier areas of Karnakaka. In addition, wood in the form of logs are used for jaggery making. Therefore, conservation of fuel for cooking, bath water heating, and jaggery making seem to be the priorities in this order. In order to implement fuel conservation programme, it is essential to have an idea of existing practice in order to

assess the acceptability of the new device. Based on this, the following strategy to conserve fuel is considered pragmatic:

(i) Assessment of present practice of cooking, bath water heating in terms of heat efficiency and conveniences.

(ii) Development of fuel efficient stoves for each of the above cases and test for its acceptance by households

(iii) Dissemination of the new stoves in villages through organised training and ecodevelopment workshops

(iv) Assessment of performance of new stoves after reasonable spread of technology and

(v) Incorporation of suggestions and solving difficulties, experimnced either in its adoptation or dissemination .

Our experience in fuel conservation started with acute shortage of fuel wood for jaggery making in Uttara Kannada which resulted in a 2 pan, bagasse fuelled efficient furnace at Unchagi, Kumta. The model was then modified with extensive experimentation at ASTRA, IISc which then gave birth to HOSA OLE. This is now called ASTRA OLE. Using similar idea, a new bath room stove has been evolved. Therefore, in these lectures, we shall take up these three fuel efficient stoves.

13.4 Conservation of fuel for cooking

In order to evaluate the performance of a stove, some standard efficiency measurements are essential. The new fuel efficient stove, e.g. ASTRA OLE has to perform in the actual field conditions. Therefore, it is essential to see how (a) the stoves can be tested, (b) to have an idea of the existing practice. Then the new stove has to be designed. These details are mentioned in the following sections.

13.5 Efficiency of cook stove

Fuel efficiencies of the stoves are measured by (a) water boiling test (b) specific fuel consumption.

(a) Water boiling test:

In this method, standard sundried wood (e.g. Matti) is used. Known weight of water is boiled on a stove by burning a weighed quantity of wood. Percentage heat efficiency was obtained as follows:

$$\text{Heat gained} = (\text{Wt. of water in kg}) \times \Delta T + (\text{Wt. of water evaporated in kg}) \times 540 \quad ..(1)$$

$$\text{Heat supplied} = (\text{Wt. of wood in kg} \times 3800) - (\text{wt. of residual charcoal in kg}) \times 6000 \quad ..(2)$$

$$\text{Percent heat utilization or Efficiency} = \frac{\text{Heat gained}}{\text{Heat supplied}} \times 100 \quad ..(3)$$

Here ΔT is the rise in temperature from room temperature to the boiling point.

Calorific value of the sun dried wood is taken equal to 3800 KCals/kg and that of charcoal equal to 6000 KCal/kg.

(b) Specific fuel consumption (SFC)

This is defined as follows:

$$\text{Specific fuel consumption} = \frac{\text{Wt. of wood burnt}}{\text{Wt. of cooked food}} \quad ..(4)$$

This method gives a figure of merit of the stove directly by comparing with the conventional stoves. Lower the value of SFC, better is the stove.

To take standard dry wood from village to village is too difficult. It is difficult to ensure that the wood used is dry and it is not possible to confirm the calorific value of the wood used. Therefore reliability of boiling water test is not good in the conditions the experiments are carried out. Villagers are not cooperative to BPT measurements since their wood was burnt without any use for them. Therefore to carryout a large number of BPT test is not feasible under the field conditions.

In the second method, however, all one had to do is to give a weighed quantity of wood while a house wife is cooking the food and at the end, just weigh the cooked food. The data obtained are thus realistic for comparison between different types of stoves. Therefore, we in in this work have carried out SFC tests.

13.6 Variety and efficiency of existing cook stoves

Before undertaking the field trials of the ASTRA OLE , a study of conventional stoves is in order. The report here is for 3 villages of Uttara Kannada, viz. Unchagi, Bhairunbe and Bengle. Schematic diagrams of different types of stoves prevalent in these typical villages are shown in Fig. 1. Percentage coccurrence of types of wood stoves, biogas and electricity usage for cooking are given in Table 1. From Table 1, we can see that in over 95 percent of the houses, wood is used for cooking in Unchagi and Bengle. Only in Bhairumbe which is a more progressive village, 8 percent of the houses have biogas and 8 percent do use electricity for cooking. Less efficient 3 stone type stoves are found in labour class families. Otherwise, slightly improved type of single and two pot stoves are prevelent in these villages. Occurrence of 3 pot stoves are rare. Isolatedly, stoves burning charcoal are also observed and on enquiry we find that they are used less frequently.

SFC measurements carried out in the conventional stoves are given in Table 2. As single pot B type stoves show high SFC with mean value of 476 $\pm$ 175 gms, whereas the C and D type stoves show a mean value of 370 $\pm$ 110 gms for standard food (rice, sambhar and sabji). Thus, the variation is quite large in both the type of stoves. The possible reasons for such large variation in SFC are:

(a) there is no standard method of construction; particularly the distances between the ground and the pot bottom vary from house to house.

(b) each family has its own skill of making stove and way of cooking.

On the whole, the results show that the conventional stoves require 430 ± 125 gms of fuel for cooking 1 kg of cooked food.

From the fuel conservation point of view, these stoves are not good for burning arecanut husk, coconut husk and fuel of small size such as twigs and shrubs. Firstly the burning rate is as high as 4 to 5 kg per hour. Due to this, large amount of ash gets collected. When the ash and unburnt charcoal collects, smoke production is high. Due to this, excessive organic volatiles are given out. Therefore, husks and dung cakes are not preferred for cooking the food inside the house. Fire incidences are high since flame is seen outside.

It should also be mentioned here that there are a few conveniences of these stoves such as vessels of most sizes can be kept on the stoves (not with same efficiency). The stoves are part of their life in terms of its construction as well as maintanence.

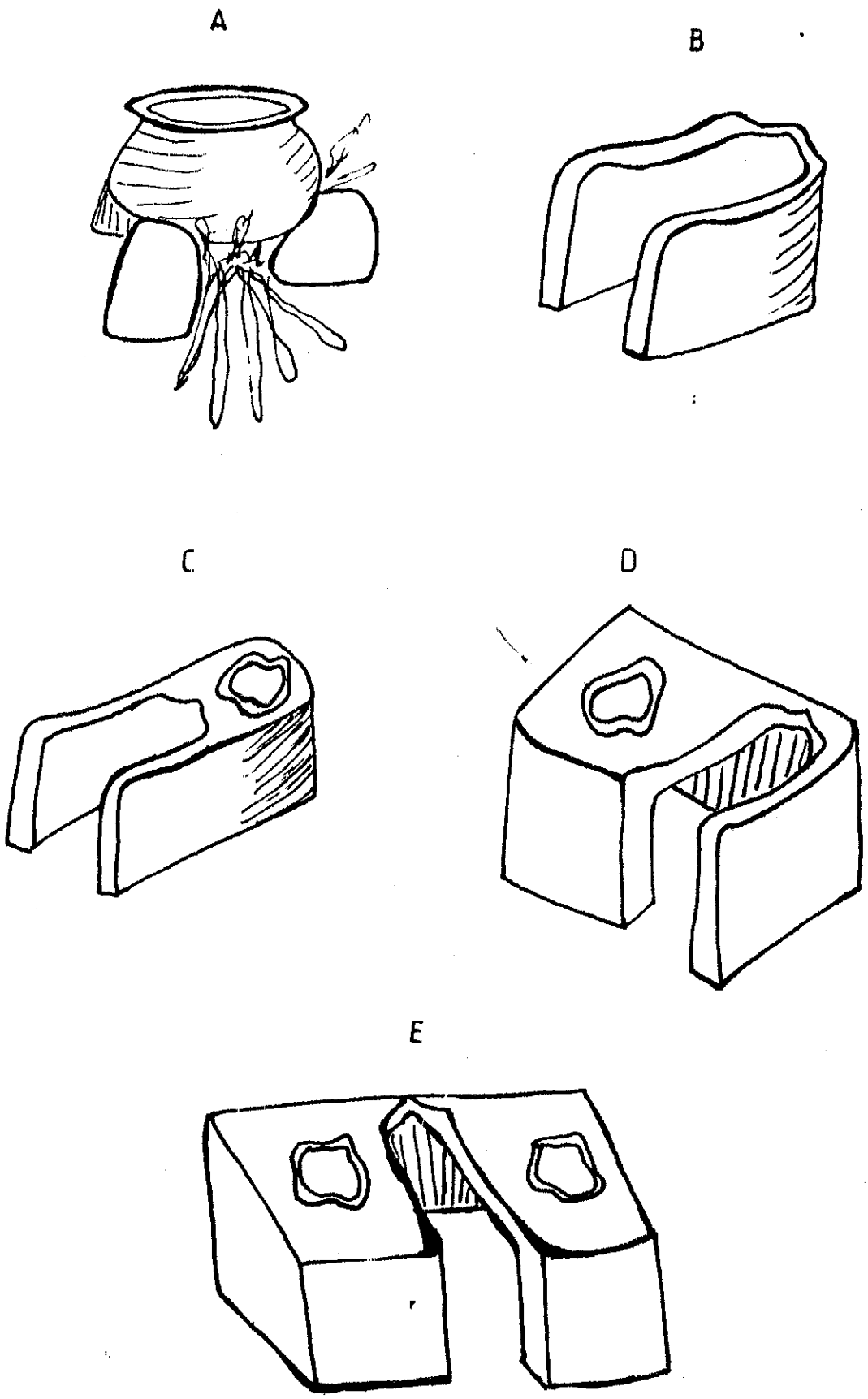


Fig 1

TABLE - 1 : Types of stoves[+] and fuel for domestic f cooking in 3 villates

Village	No.of houses	Type of stove	Percentage occurrence	SFC mean value
Unchagi (Kumta) 363 people	63	A	50	445 gms/kg
		B	20	440 gms/kg
		C	28	350 gms/kg
		Biogass	2	-
		Electricity	Nil	-
Bhairumbe (Sirsi) 430 people	62	A	2	450 gms/kg
		B	42	430 gms /kg
		C	38	358 gms/kg
		Biogass	8	-
		Electricity	8	-
Bengle (Sirsi) 874 people	153	A	nil	-
		B	49	432 gms/kg
		C	47	363 gms/kg
		Biogass	4	-
		Electricity	nil	-

[+] This data above is before construction of ASTRA OLE. Till July 1984, 50 pgrcent in Unchagi, 11 percent in Bhairumbe and 21 percent in Bengle houses has ASTRAOLE

TABLE - 2 : SFC Values in different types of conventional stoves

Sl. No.	Name	Place	Type of stove	SFC in gms of wood/ kg of food
1.	K.S.Hegde	Sirsimakki	A	450
2.	Masti Hulia	Bhairumbe	C	313
3.	K.G.Hegde	Bhairumbe	B	380
4.	A.M.Hegde	Bengle	C	314
5.	D.G.Hegde	Bengle	C	701
6.	Y.S.Hegde	Onikeri	C	534
7.	Holelinga	Bengle	B	561
8.	Manjunath	Sirsi	C	361
9.	Mahadev Yallapa	Sirsi	B	431
10.	Gulya Tai Bangari	Bengle	C	351
11.	G.Ramappa	Sirsi	C	463
12.	T.R.Shastri	Terkanalli	B	295
13.	Shire Gouda	Bhairumbe	C	327
14.	G.C.Hegde	Onikeri	C	322
15.	V.G.Hegde	Onikeri	C	336
16.	K.R.Hegde	Onikeri	C	271
17.	Kenya Thakur	Bengle	B	736
18.	Abdul Khadar Abubkai Shetty	Sirsi	C	314
19.	Venkatesh C.Siddanur	Sirsi	C	348
20.	Venkappa Lansappakenade	Sirsi	B	309
21.	Somya Tai	Bengle	B	864
22.	V.G.Hegde	Kallabe	B	380
23.	Narasimha	Kallabbe	B	408
24.	Hanumanna Naik	Bidrahalli	C	415
25.	Timma Nair	Bidrahalli	B	426
26.	Narayan Manj	Bidrahalli	B	397
27.	Ishwar Naik	Bidrahalli	A	438

13.7 Design criteria of new stove - ASTRA OLE

The new stove viz. ASTRA OLE is designed to meet the following criteria:

(a) The stove a 3 pot one so that 3 dishes can be cooked simultaneously.

(b) The burning be more efficient and any type of fuel can be burnt.

(c) Efficiency be high and SFC be low for saving fuel,

(d) Be smokeless, easy to light, easy to maintain flame, easy to extinguish

(e) It should be easy to construct at the site using locally available materials and the most important factor, the cost be very low.

The stove has been designed and tested by the group headed by Professor R. Kumar of IISc [3] and presently it is in this fields for its extention and extensive use. As will be clear latter, the stove is a smaller version of a 3 pan community jaggery unit introduced at Urchagi in the year 1981.

13.8 Controlled combustion

For burning fuel, air is needed. Fuel containing carbonacious materials burn in air (O_2) giving CO_2 and H_2O as the products and this reaction being exothermic heat is generated. Two important principles have been made use of in this new stove. They are:

(a) Burn the fuel on a cast iron grate; required air is allowed through the holes of the grate so that air is properly mixed with the fuel.

(b) Only required amount of air is allowed through the grate by closing the fuel box and by by providing ducts below the pans.

No other stove which claim high efficiency use these two principles.

Other important features are:

(c) Pots are dipped sufficiently so that maximum heat transfer is achieved for cooking.

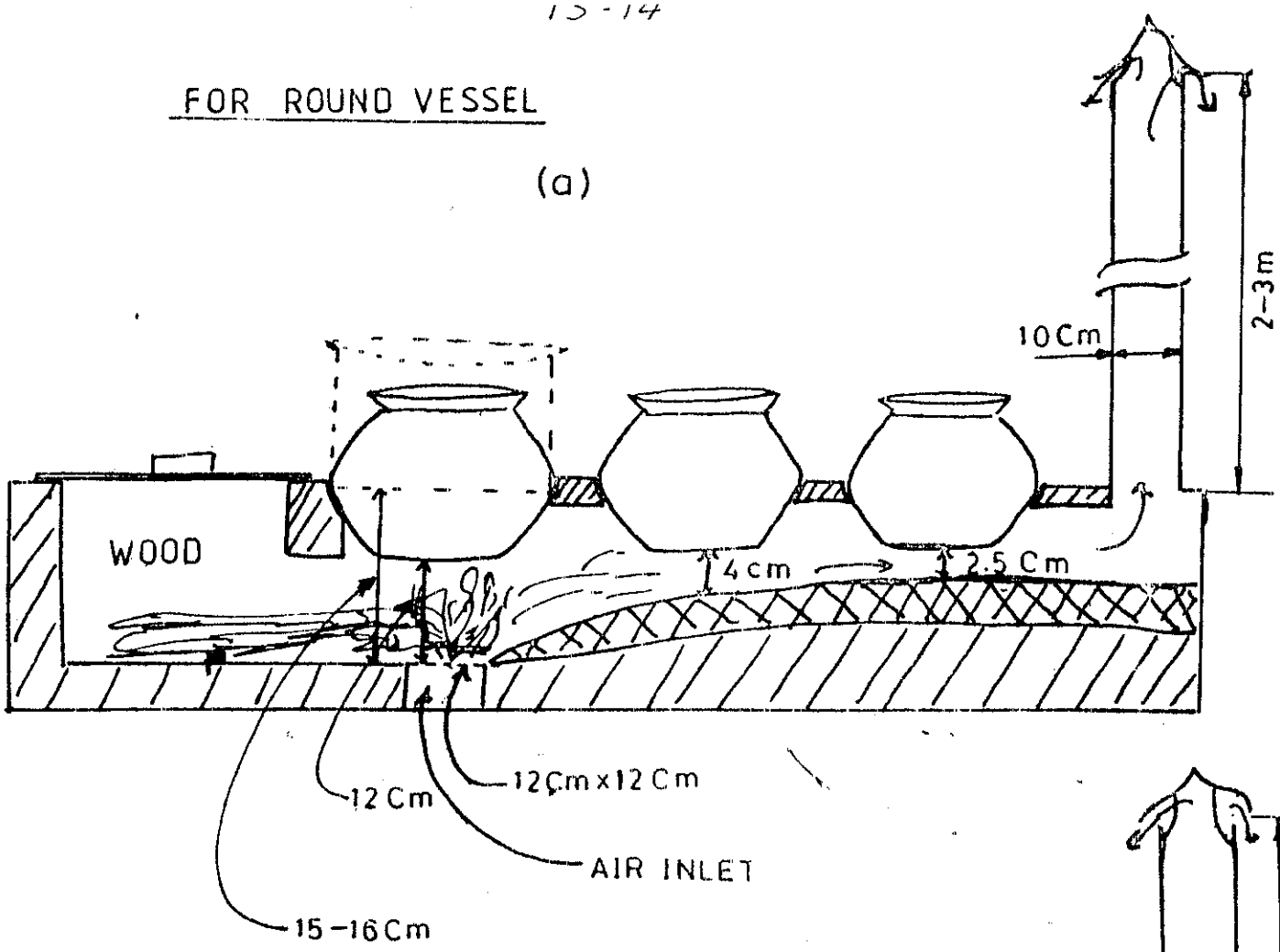
(d) Distances between the pot bottom and the stove are adjusted so that maximum heat is extracted by the pots.

Cross-section of the ASTRA stove describing these features are given in Fig. 2. Notice the type of vessel in Figs. 2(a) and (b). The distances 12 cm., 4 cm. and 2.5 cms. below the first, second and third pans are very critical to achieve high efficiency.

The size of the grate is fixed on the basis of amount of fuel that can be burnt for one hour; generally on a 15 cm x 15 cm grate area, 1.5 - 2 kg of fuel can be burnt which is sufficient for cooking rice, sambhar and sabji for 6-8 people. If the vessel size is high the grate size can to be increased.

FOR ROUND VESSEL

(a)



(b)

FOR FLAT VESSEL

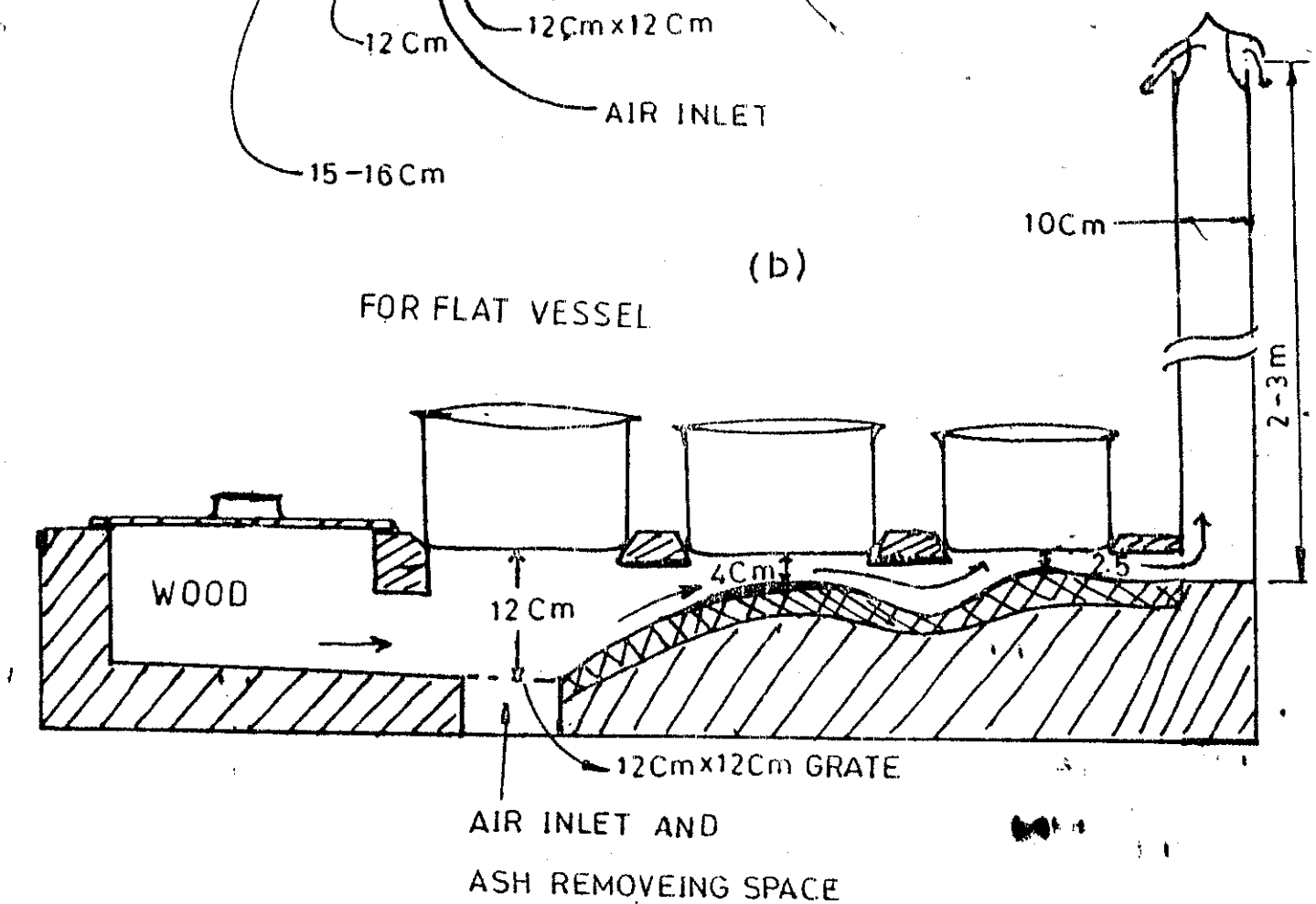


Fig. 2

Yet another point to be noted is the 4-5 cm thick rice husk-mud layer given in the stove. This helps in reducing heat transfer to the walls of the stove. The chimney used is 10 cm dia., 1-1.5 meter high which sucks the hot air and leaves it outside the oroof.

Extensive experimentation in the laboratory was needed to get the dimensions of the stove.

13.9 CONSTRUCTION OF 'ASTRA OLE'

An instruction manual on the construction of ASTRA OLE has been published in Kannada by IISc/KSCST, Bangalore. Some of the important steps of construction is given here. For details the manual may be consulted.

Materials for construction of new stove

(a) Latterite stones (15) 25 cm x 30 cm x 30 cm

(b) Cast iron grate (1) 15 cm x 15 cms

(c) Abbestos cement pipe (1) 10 cm dia x 1.5 meter height

(d) G.I. sheet (1) ; 30 cms x 50 cms area; 20 gauge.

Other than this, locally available tile pieces, sand, mud, rice husk are required.

Window for inlet made of G.I. sheet required is shown in Fig. 3A. Two hooks are welded to the window which can be embedded in the wall of the stove.

Fuel box cover can be of simple design as shown in Fig. 3B. The length and breadth can be varied depending upon the length of the wood pieces. Generally 50 cm x 30 cm cover is sufficient.

Bridges between the first and the second hearth of the stove can be simply 4 cm x 25 cm Mangalore tile pieces. Iron rods rolled into thin wire mesh can be used. Iron bars of 4 cm x 25 cm can be used. These are shown in Fig. 3C.

To keep smaller vessllls, a lid with hole in the centre serves the purpose (see Fig. 3D). The lid can be of mud or tin sheet.

Choice of place : In the kitchen, an area of 175 cm x 40 cm is sufficient to construct 3 pot ASTRA OLE. The direction of the stove be fixed so that the convenience to push the fuel in right hand is possible and facing east while cooking. Secondly, stove be constructed such that chimney comes towards low roof end of the kitchen so that chimney goes out of the roof for smoke to be left outside the kitchen.

Choice of vessels : Choose 3 vessels which are most commonly used for cooking such as rice, sambhar, dal or subji, ragi etc. If the vessels are round bottom it is better from the point of efficiency of the stove. Flat vessels can also be used. Measure the highest diameter of the vessel as shown in Fig. 3E.

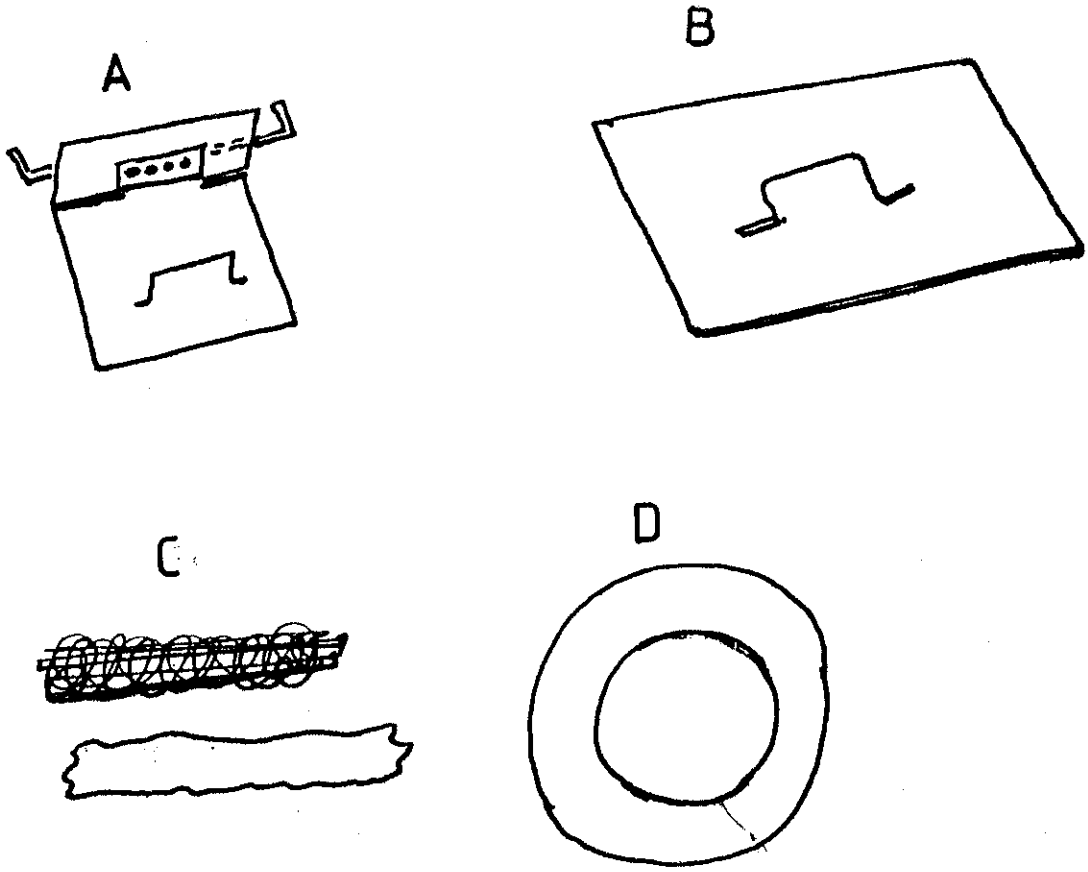


Fig. 3

Construction of the stove : Steps

(1) Mark the area 175 cm x 40 cm. Mark the direction of the chimney position and the fuel box at the other end as shown in Fig. 4a. Keep the 3 vessels chosen in succession leaving about 75 cm for fuel box and 425 cm between the vessels. Mark the position for the first vessel.

(2) Construct a wall along the wall of the kitchen either with bricks or lattrite stone. Height of the wall be about 2 brick height (20-22 cm) and leave about 60 cm for fuel box and keep two half cut bricks as shown in Fig. 4b, to keep the grate. The distance between the brick support for grate be 12-13 cm. when 15 cm x 15 cm grate is used. Keep the grate such that wood when placed on the grate will be perpendicular to the channel of the grate.

(3) Now,construct the second will as shown in the fig. 4c. and 4d. The inside distance between the walls should be equal to the highest diameter of the vessel used.

(4) Keep now a stone above the bricks supporting grate and notice that an air inlet and the ash removing place below the grate gets formed. Now complete the construction of the wall for fuel box till the height is only 20-22 cms as shown in Fig. 5a,b. Also fit up the

air inlet window at the ash removing place.

(5) Keep the first vessel now above the grate such that centre of the grate is about 2 cms towards chimney side with respect to the centre of the vessel. Even if the grate is exactly below the first vessel no harm is done. Now keep two bridges at each side of the vessel across the channel as shown in Fig. 5b.

(6) Measure the distance between the bottom of the vessel and the grate. Put the mud on the walls and keep the bridges such that the distance is 11 cms exactly. This is most crucial. Now give tile pieces and other packages after keeping vessel towards the corners and put rice husk - sand - mud mixture. Shape the top part round by turning the vessel on the wet mud. Leave it at that.

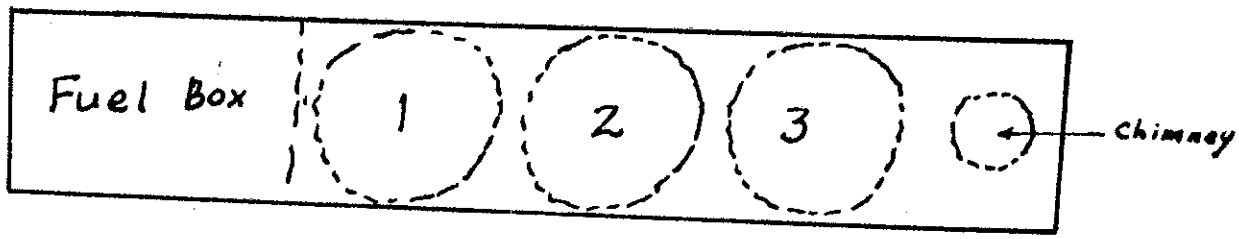
(7) Keep a bridge now to keep the second vessel and shape the top as is done for the first vessel.

(8) Similarly, make the third hearth by eeeping the third vessel.

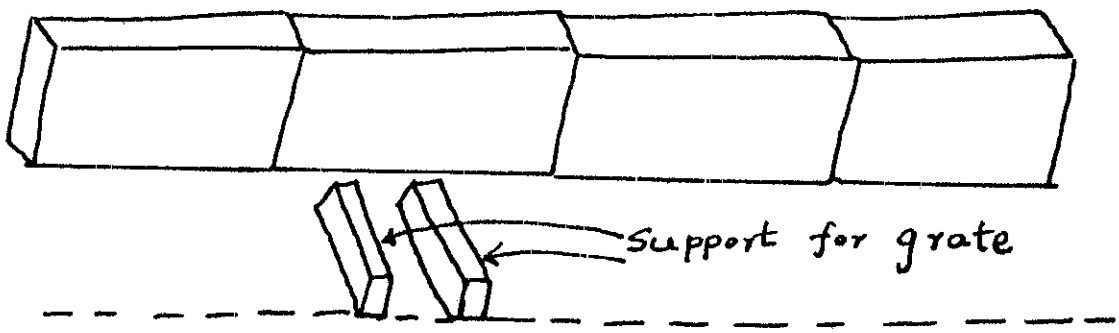
(9) Keep good support for chimney and mount the chimney on the channel. Chimeney bottom is not to be blocked.

(10) Now take rice husk - mud - sand (1:1:1) mixture and shape the inside of the stove. Firstly, cover the

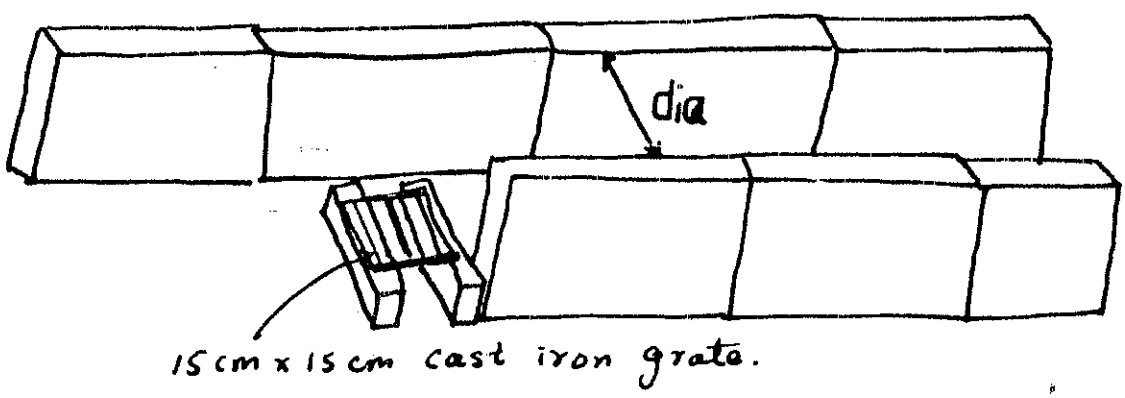
a


Fuel Box
1
2
3
Chimney

b


Support for grate

c


dia
15 cm x 15 cm cast iron grate.

d

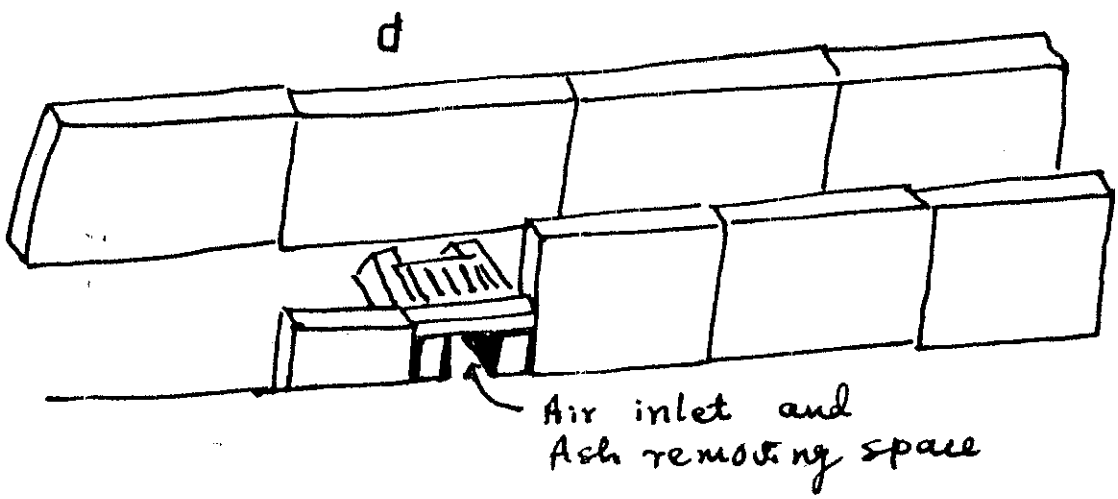
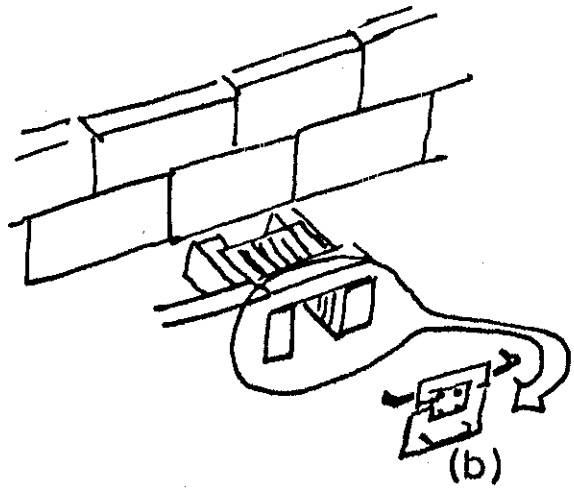
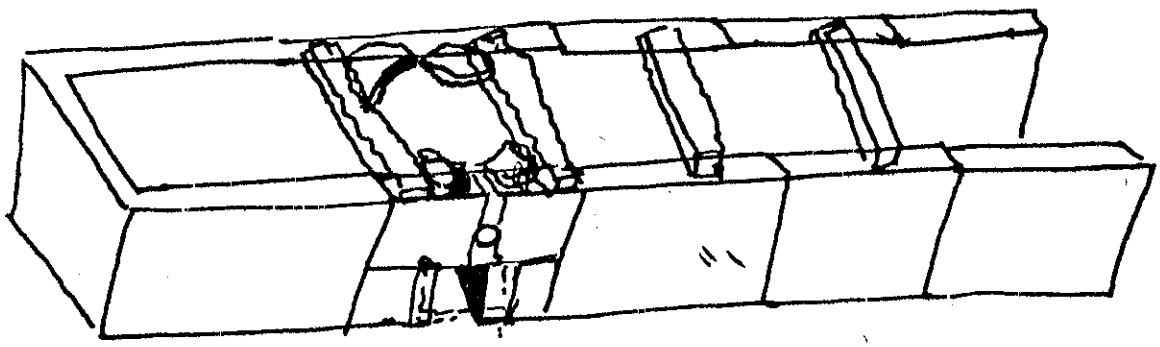

Air inlet and
Ash removing space

Fig 4

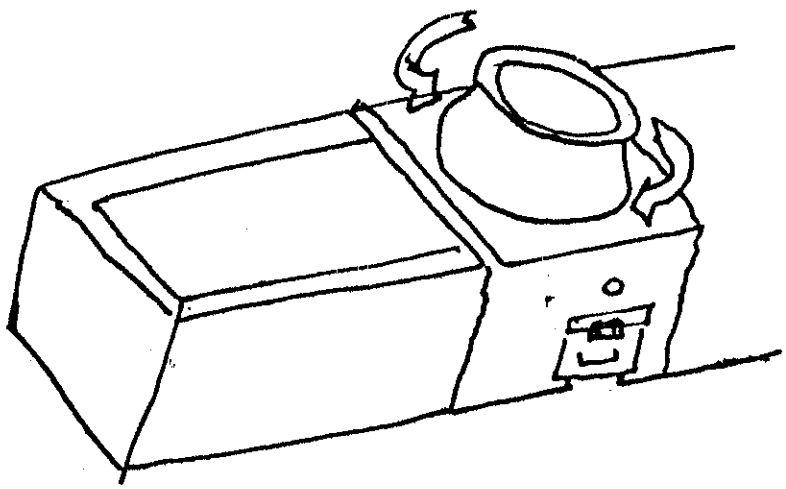
(a)

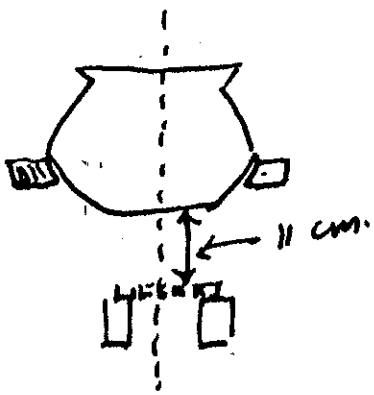


(b)



(c)





(d)

Fig. 5

wood box bottom level to the grate level with mud. Then only the grate is kept uncovered but it should be fixed with mud. See that air can come only through the grate and all other gaps should be closed. Put mud mixture below the second and third pots. If round vessels are used, shape the inside exactly as that of the vessel bottom and see that distance between top layer of the mud mixture and the bottom of the second vessel is only 4 cm. The distance between the first pot bottom and the grate is already adjusted to 11 cms.

(11) Similarly pack with mud below the third pot and shape it so that top layer of the third hearth is only 2.5 cm to the bottom of the pot. Below the bridges between the first and second pot, keep large gap for flame to be seen by the second pot. Also keep sufficient gap below the chimney for the flue gas to escape.

(12) Keep 1 cm diameter hole in the wall above the air inlet gap. The position of the hole should be just about at the bottom level of the first vessel. This is called secondary air inlet which helps burn combustible gases (see Figs. 6a,b,c).

(13) Plaster the fuel box as well as outside of the stove so that the top level is same throughout. Now again, take care that 11 cm, 4 cm and 2.5 cm gaps are maintained below first, second and third pots. Distance between the vessels can be 4 cm to 5 cm.

(14) Now put the lid for the fuel box. See that there is no gap and it is properly closed.

(15) Smoothening of the stove can be done now and finally the stove can be covered with cowdung and cleaned. Fine cracks get closed due to the fine fibres in the dung. On continuous curing, the stove becomes hard. Make sure that every time the curing is done, vessels be placed on the stove and there should be no gap between the stove and the vessel.

(16) After about 10 days, stove is dry and is ready for firing. Cross-sectional view for round and flat bottom vessel stoves are given in Figs. 2a,b.

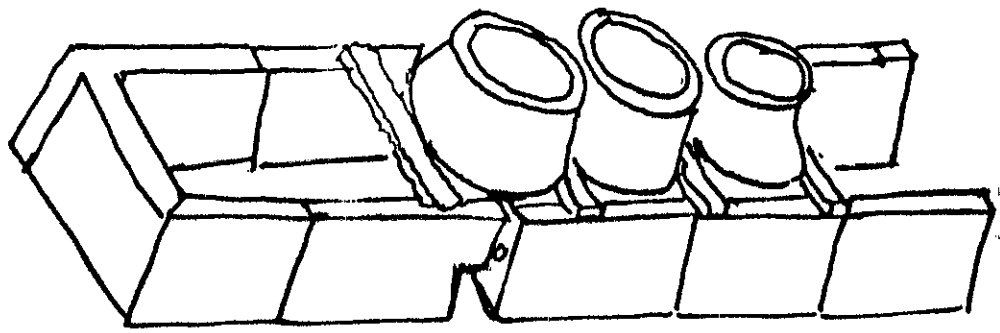
Lighting method

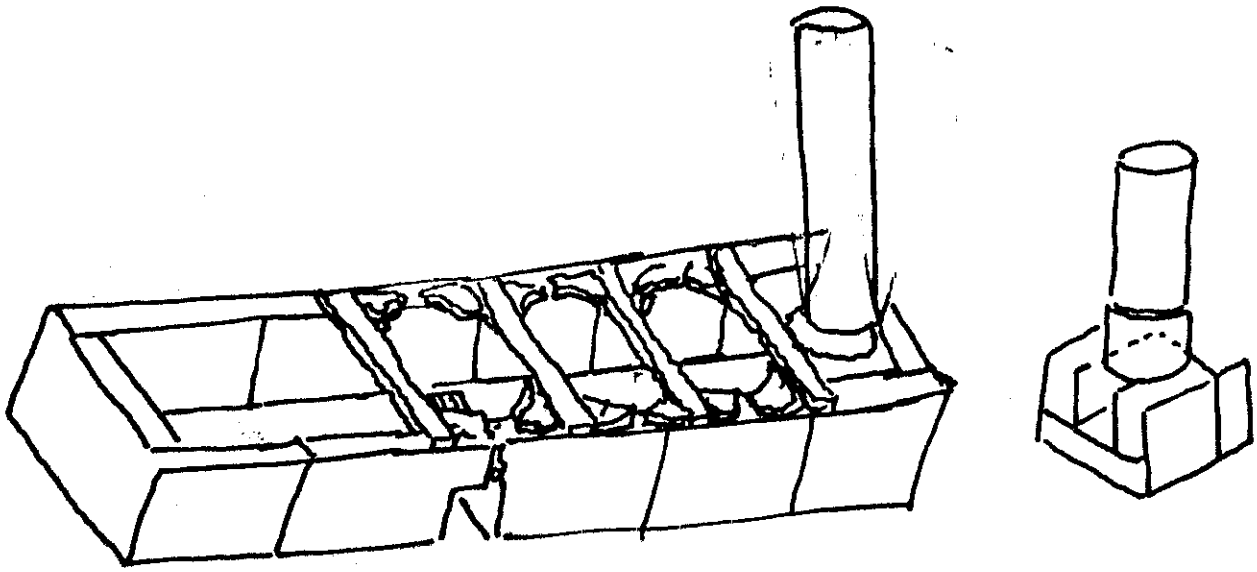
Put small quantity of easily combustible palm on the grate and light it, wait for a minute. Now cover the fuel box. Put the first vessel on the stove. Wait for a few seconds. Then keep the second vessel and the third vessel.

Put some wood on the grate now and close the fuel box. Now the smoke escapes through the chimhey. Sometimes smoke comes through fuel box because the stove is still wet. Continue to burn the fuel. In about 5 minutes stove starts working well. Push the fuel once in 8-10 minutes and keep the fuel box covered while cooking. In case it is not burning, fan through the air inlet hole, instantly fuel gets lighted. Ash falls below the grate and can be removed once a day.

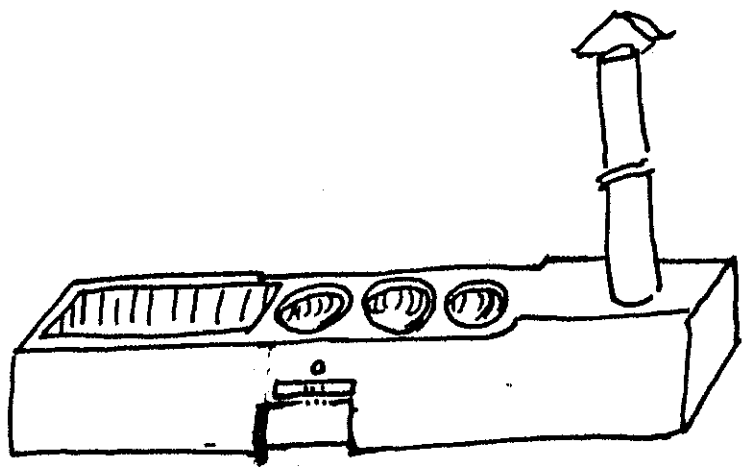
13-24

(a)





(b)



(c)

Fig.6

13.10 Performance of ASTRA stoves in Uttara Kannada villages

SFC measurements carried out on the new stoves are given in Table 3. The SFC values compared to the ones obtained in conventional stoves in Table 2 are quite encouraging. The mean SFC is 158 gms with a standard deviation of 20 gms. Taking the mean values of SFC in conventional stoves and the new one, the saving in wood is over 60 percent.

The stoves mentioned here are only the randomly chosen ones out of over 100 stoves constructed under this programme. Since the variation in SFC is not large, we can be reasonably sure that the stoves can be propagated with this kind of saving in fuel. SFC data shows that the stoves can be built which can give SFC between 150-170 gms with 95 percent confidence limit.

One important point to be noted here is that there were no restrictions in the type of vessel to be used in these stoves. Vessels which they have been using in the stove were used in the new one. Also there was no differentiation between aluminium, mud, brass, copper or stainless steel in which they cooked. It is possible that if only round bottom vessels are used, one could reduce the SFC values further. This however puts a serious limitation on the propagation of the

stove. When flat bottom vessels are used in stoves constructed for round bottom vessels, efficiency falls drastically Therefore a stove primarily meant for a flat bottom vessels which of course can be used with round bottom vessels of slightly higher dimensions is more suitable in this region.

Yet another factor for this choice was for making the stove more universal for cooking different kinds of food other than rice, ragi, sambhar. In Uttara Kannada, morning breakfast with Dosa or Idli is a common practice. As is well known,'dosa'making pan as well as'idli' vessels are flat bottom ones. It was fo nd that the stove constructed for round bottom was not convenient for Dosa preparation. High heating rate required for this purpose was not achieved. Considering all such local requirements, a stove based on Fig. 2b is found more suitable in this region.

13.11 Propagation of ASTRA OLE

A simple description and demonstration of the new stoves in 5 villages was not sufficient for easy propagation. Since there are certain critical parameters in construction, only a trained person could build it to reproduce it with good efficiency. Therefore training of local people was found assolutely essential for propagation.

TABLE - 3

Sl. No.	Name	Village	SFC in gms of wood/kg of food
1.	R.S.Hegde	Bellekeri	144
2.	I.S.Hegde	Kallabbe	175
3.	R.A.Hegde	Sankal	181
4.	S.S.Hegde	Kallabbe	144
5.	U.S.Hegde	Kotegudde	161
6.	G.S.Bhat	Kotegudde	202
7.	S.G.Achari	Unchagi	171
8.	S.S.Gouda	Unchagi	181
9.	B.Tai Bangari	Bengle	165
10.	Kempa Chennashetty	Bengle	161
11.	Rajanna Viradashetty	Bengle	177
12.	Linga Tunde Beery	Bengle	189
13.	Keriya Tandechedya	Bengle	172
14.	Somya Tai Bangari	Bengle	158
15.	Keriya Tahkur	Bengle	150
16.	Bangarya Tarde Iddappa	Bengle	133
17.	Gulya Tai Bangari	Bengle	132
18.	S.P.Hegde	Bhairumbe	160
19.	M.V.Shastri	Unchagi	150
20.	S.S.Hegde	Bhairumbe	126
21.	M.V.Hegde	Onikeri	160
22.	G.G.Hegde	Onikeri	134
23.	S.R.Hegde	Unchagi	160
24.	P.V.Shanbhage	Unchagi	111
25.	S.V.Bhat	Unchagi	150

completed the 5th stove, he was confident and the stove performance was very good. Therefore 5 stoves per group was fixed for a training programme.

Over 15 training camps have been held in Uttara Kannada only and about 5000 ASTRA OLE are being in use.

13.12 Fuel efficient bath room stove

It is common knowledge that people in India take hot water bath. Hot water is known to give comfort after a hard work. Children are invariably given hot water bath. Therefore, we need energy to heat water for bath. We considered it worthwhile to take up the problem of saving energy in this domestic sector. A brief description of conventional stoves and the design and development of the new fuel efficient bath room stove is described here.

13.13 CONVENTIONAL BATH ROOM STOVES

Efficiency : Fuel efficiency of a stove is generally evaluated by water heating test. Heat gained by a known amount of water is measured by burning a measured quantity of wood. Hard fuel-wood such as casurina, sun dried for 30 days, contain about 10 percent moisture. Calorific value of this type of wood is 3800 kCals/kg. Efficiency is obtained as follows:

$$\%\text{heat utilization} = \frac{(\text{wt. of water in kg})(\Delta T)}{(\text{wt. of wood burnt in kg}) \times 3800} \times 100$$

where ΔT is the rise in water temperature after burning.

Now, several training camps have been held by the trained teachers under KSCST. The mode of training is as follows:

a) A simple lecture cum demonstration of the new stove;

b) Select a group of 10 trainees (to be selected by local organisations such as Yuvaka and Mahila Mandalis, Schools and Coooperative societies).

c) Select 5 houses for each pair of trainees.

d) Demonstration of different stages of fabrication at the training centre by a trained person.

e) Fabrication of at least 5 stoves in the kitchen of the selected houses by the trainees.

f) SFC measurements in conventional stoves and the new stove by the trainer for making the trainees realize the fuel saving in the new stove and the added conveniences.

g) SFC measurements by the trainees in the stoves they have built.

During the first training cum demonstration camp at Yadahalli, there were 4 to 5 people in a group and only one stove per group was built. Follow-up of these trainees showed that such a short course was insufficient. The second camp was held at Unchagi with 8 groups consisting of two each and 8 trainers. Each group fabricated 5 stoves with a total 40 stoves during the training programme (Jan. 1984). By the time a trainee

Generally, bath water is heated to 60° and bath is taken after mixing fresh water. We have also heated water to about 60°C in our experiments.

Conventional Bath room stoves

A survey of bath room stoves in the villages of Uttara Kannada showed that no family used more than one vessel. Mainly, 4 types of stoves are found in these areas which are shown in Fig. 7. Efficiencies of each of these types were measured and the values are given in Table 4 along with percentage occurrence of each type and their brief descriptions. Invariably, a round vessel made of copper is used. Size of this vessel varied depending upon the family size. For a family of 6 members, 50 to 60 liters capacity vessel is in usage.

From Table 4, we can see that efficiency of the stove increased with usage of a chimney. Highest efficiency of the bath room stove we measured is only 22 percent. However, most stoves do not have chimney and their efficiency is less than 15 percent. Yet another observation is that these stoves are smokey. Bath room walls and roofs are generally covered with dark tarry layers. It is uncomfortable to take bath while stove is burning. Smokeless bath room stove is considered desirable by these villagers in addition to fuel saving. Thus, there was a clear demand by the villagers for a new smokeless, fuel efficient bath room stove.

13.14 Design considerations of a new bath room stove

Based on the observations on the conventional stoves and the discussions we have had with the villagers, the criteria for a new stove desired were:

(a) in the new stove the existing single vessel be used,

(b) locally available material be used for construction,

(c) the stove be easy to construct, easy to light, easy to extinguish and smokeless,

(d) rate of burning be such that in about 30 min, about 50 liters of water be heated to 50°C,

(e) cost of the stove be kept at a minimum, and

(f) high fuel efficiency be achieved.

With these constraints in view, design parameters are calculated as follows:

Unlike in the conventional stoves, fuel is allowed to burn over a cast iron grate. Air required for burning is allowed through the grate so that combustion is controlled. Taking 50 liters round bottom vessel to be heated from 25°C to 50°C in 30 minutes and assuming 35 % efficiency, quantity of wood to be burnt is calculated. Calorific value of wood is taken equal to 3800 kCals/kg. Thus, 1250 kCals of heat is required for heating 50liters of water from 25 to 50°C and the wood required for this is 1250/(3500 x 0.35) = 0.940 kg. Now, this much wood should be burnt in 30 minutes. It is known that

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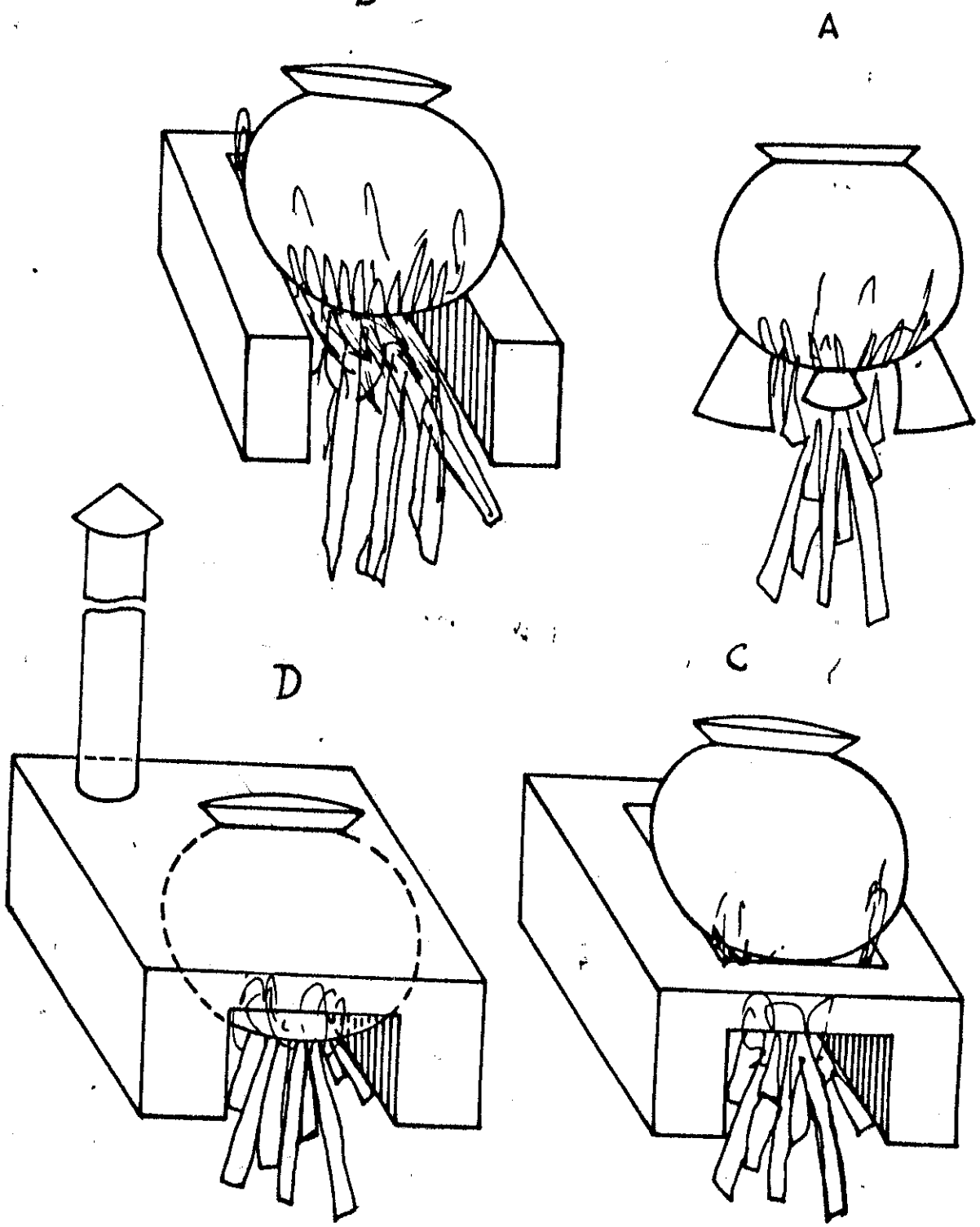


Fig. 7

TABLE - 4 : Efficiency and percentage occurrence of the existing bath room stoves+

Type (see Fig.1)	Percentage occurrence in a typical village Unchagi; cut off	Percentage heat utilization	Special features
A	25	Lo.12	no grate, no chimney
B	30	12-15	no grate, no chimney
C	40	14-16	no grate- no chimney
D	5	16-22	no grate, chimney of 3 in-4 in dia., 10 ft. height

+ Efficiency presented here is an average of 5 stoves of each type studied.

about 2.5 kg of wood can be burnt in one hour over a grate area of 15 cm x 15 cm (~ 6 in x 6 in). Hence a kg of fuel can easily be burnt in about 30 minutes over this grate area and hence a 15 xm x 15 cm cast iron grate is fixed. Flue gas generated has to be taken out through chimney and 10 cm x 2 meter chimney is considered adequate for this purpose. Standard 4 in x 10 ft asbestos cement pipe available in market is close to this requirement. The fuel is to be laid on the grate and the fuel can be kept closed so that air required for burning is allowed only through the grate. Thus, the final design parameters were:

(a)	Grate	15 cm x 15 cm
(b)	Chimney	10 cm x 2 m
(c)	Vessel sizs	50 lit. capacity
(d)	Fuel	1 kg of wood
(e)	Distance between the grate and vessel bottom	To be fixed after the experiments.

Efficiency of an experimental new stove

In order to examine the effect of various stove parameters on efficiency, an experimental stove was constructed at Mr.S.R.Hegde's house, Unchagi. The stove was constructed out of lattrite stone and mud. Over 30 efficiency measurements were carried out by varying (a) the distance between the grate and the pot bottom,

(b) distance between the wall of the vessel and the stove wall, (c) duct size for flue gas. The air gap below the grate was kept the same, viz., 12cm x 2 cm by partially closing the hole below the grate which also serves as ash removing hole. The result of these experiments are summarized in Table 5. We can see from the results that the most important parameter is the distance that the grate and the pot bottom. At 12 cm., the highest efficiency of 40 percent was achieved when the wall gap was about only 4 cm. The duct size was only 10 cm x 10 cm. We have also measured the variations of water temperature, flue gas temperature and the temperature of the combustion zone (2 cm above the grate) as a functioning time. The stove can be operated at as low a flue gas temperature as 130°C. The results also show that in about 45 min., 0.9 kg of wood can be burnt and 50 liters of water can be heated from 28° to 55°C with 40 percent efficiency. These results indeed satisfy the criteria considered in the design of the new stove. The stove was smokeless. The cooling rate of water was 1° per hour at 60°C initial temperature.

13.15 Fabrication of the new bathroom stove

Steps to sconstruct the stove are given below:

(a) Firstly, choose the direction of the fuel feed, chimney and the ash removing place as shown in Fig. 8a.

TABLE - 5 : Variation of efficiency with varying the critical parameters; air gap below the grate (2 cm x 12cm)

Sl. No.	Distance between pot bottom and grate	Annular space between vessel and wall of the stove	Efficiency PHU (percentage)
1	18 cm	5 cm	25
2	15 cm	5 cm	32
3	13 cm	5 cm	36
4	12 cm	5 cm	32
5	12 cm	4 cm	40

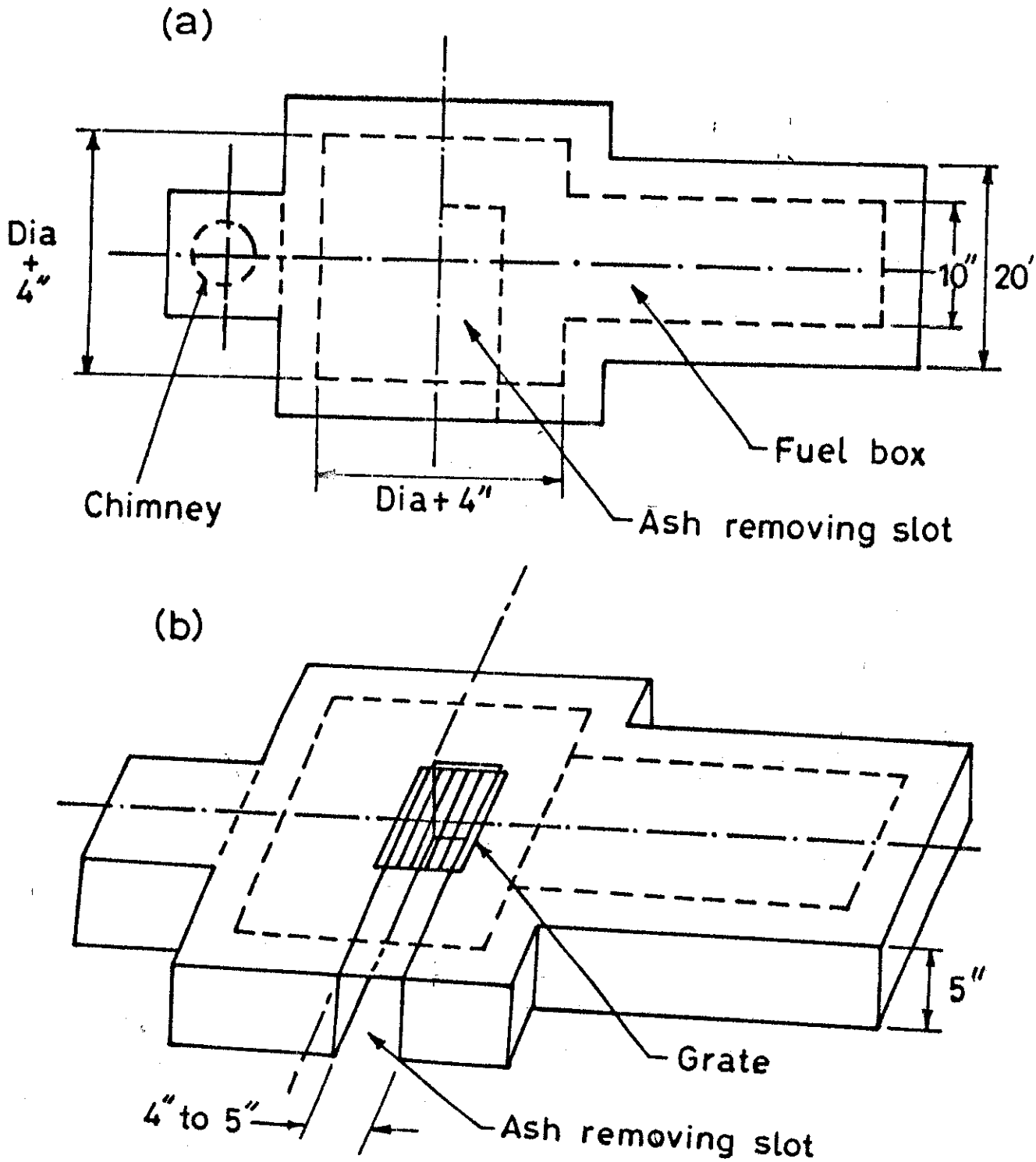

(a)
Dia
+
4"
10"
20'
Chimney
Dia+4"
Fuel box
Ash removing slot
(b)
5"
Grate
4" to 5"
Ash removing slot

Fig. 8

Measure the (highest) diameter of the vessel which we call dia. Consider the wall thickness of about 5 in. Then accordingly, mark the space as shown in Fig. 8a. Mark the positions of the grate such that the grate is placed from the center towards the fuel feed hole.

(b) Construct a platform of 5 in height leaving the grate mounting place along with ash removing place as shown in Fig. 8b. Place 6 in x 6 in grate on the channel. Make sure that channel direction of the grate is perpendicular to the fuel feeding direction. This is shown in Fig. 8b.

(c) Now construct the walls as shown in Fig. 9. Keep the inner distance between the square walls equal to dia + 4 in for vessel and the air gap. Keep the channel for ash removing free and also for fuel feed as shown in Fig. 9. Continue to increase the wall height by keeping about 8 in x 8 in gap for fuel feed. This can be seen in Fig. 10.

(d) Give a brick support at the bottom at the center (towards chimney side) and keep the vessel such that the bottom of the vessel is only at 12 cm and adjust the height of thw awall. Then remove the vessel.

(e) Shape the bottom and the inside tof the stove exactly as that of the vessel keeping 2 in gap uniformly

between the vessel and the inside wall. This is the most important step in the stove construction. The filling should be done with mud and rice husk mixture (50:50). Support the vessel by giving the packing on the wall side and the bottom brick such that the distance between grate and the bottom of the vessel be 12 cm (~ 5 in). Then at the chimney end, keep a 4 in x 5 in gap and lead it to chimney. Close the top now by covering with tile or asbestos pieces and finally with mud. The cross-section of the stove now looks as in Fig. 11. One can provide a lid in the flue gas duct path to remove the carbon collected over a period of time.

(f) Another way to construct is to support the pot from the maximum diameter of the vessel itself. The wall height can be reduced and construction is easy. Although the efficiency of this is about 1 percent lower, constructions is easy and it is suited for villages.

(g) Make the fuel box of about 10 in wide, 25 in long and make a lid of 18-20 gauge G.I. sheet to cover it.

(h) Finally plaster the outside walls and top of the stove with mud, sand and lime mixture with a final coating with cement. Fuel box also needs plastering. Make sure that when the fuel box is covered with lid, no air gap is left. Top part of the stove needs cement plaster because water should not enter the stove.

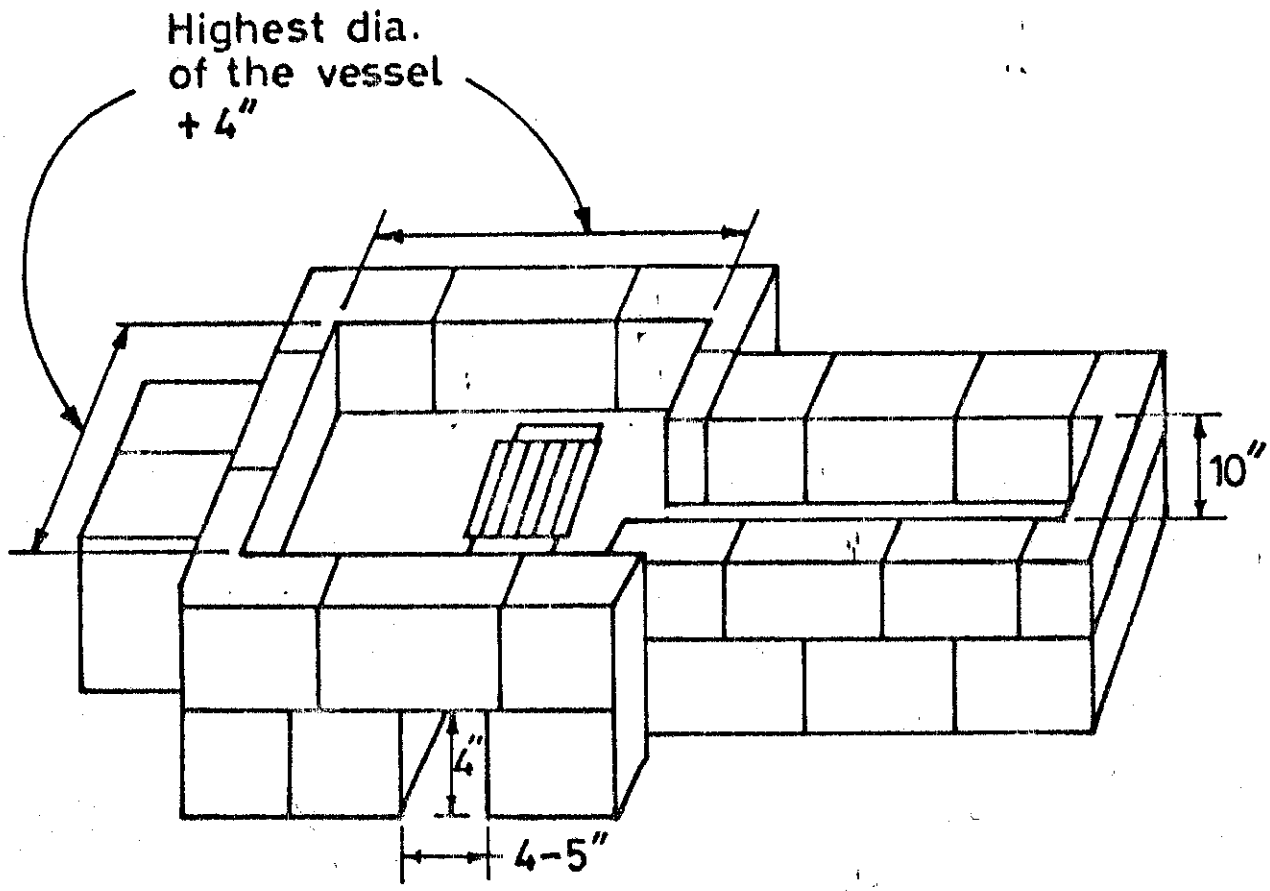


Fig. 9

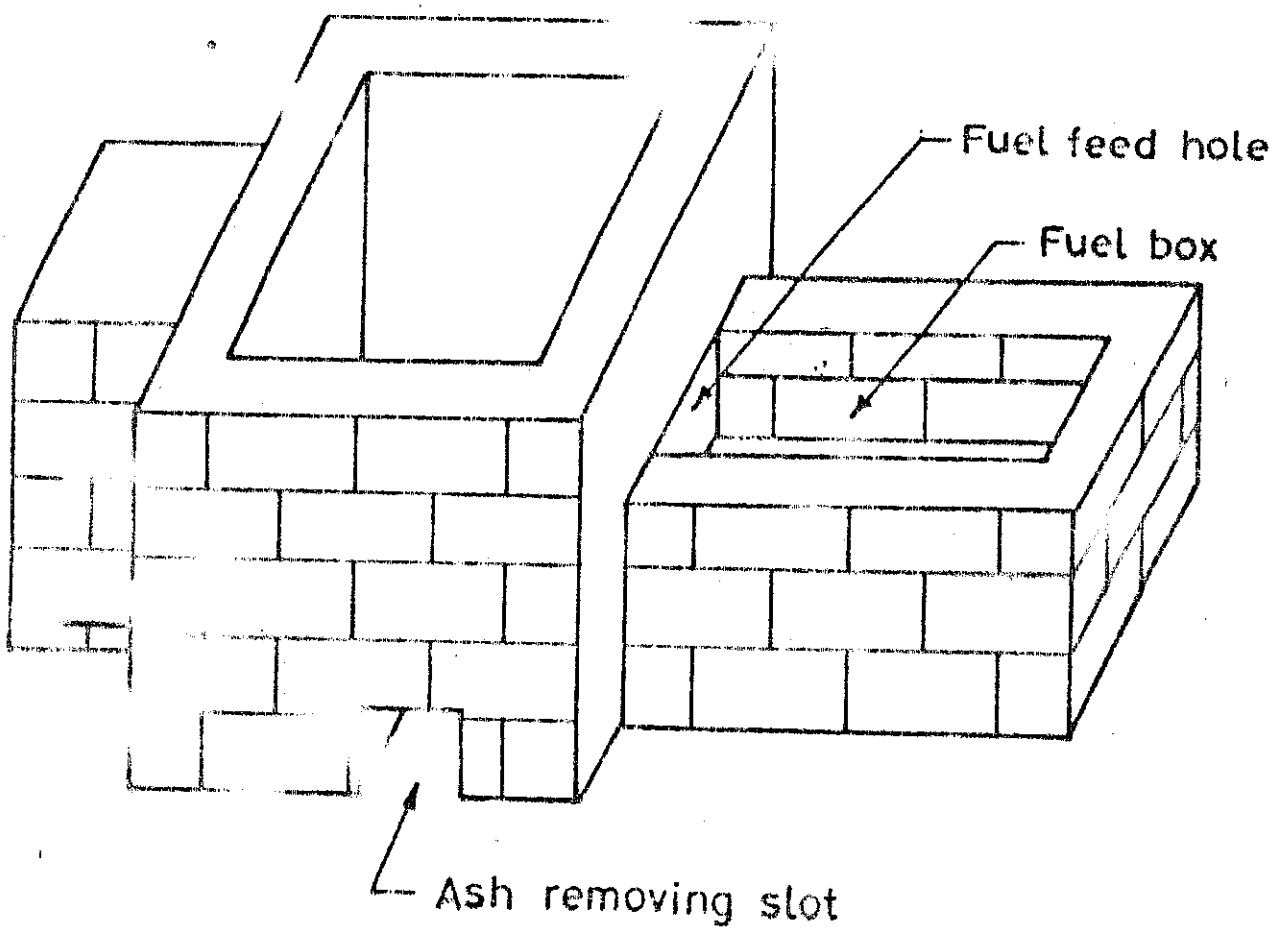


Fig. 10

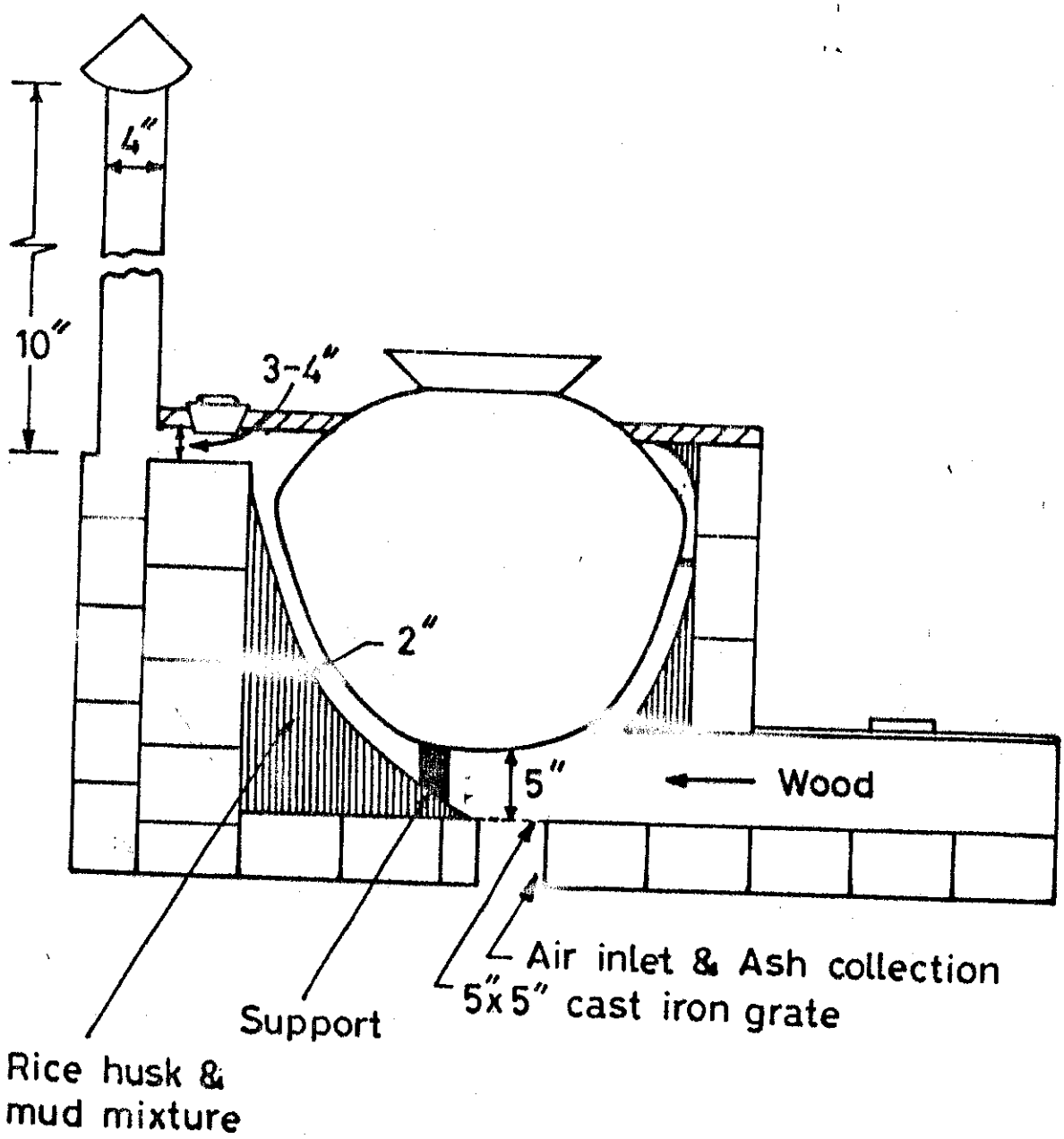

4"
10"
3-4"
2"
5"
Wood
Air inlet & Ash collection
5"x5" cast iron grate
Support
Rice husk &
mud mixture

Fig. 11

Firing procedure

The stove be allowed to dry for 8-10 days ; put plam leaves or any light material on the grate and put fire. Cover the fuel box with the lid. Flue gas starts going out through the chimney. Put smaller sticks on the grate now and finally, use cut wood or any other fuel for burning. Keep the fuel box closed and air shall enter only through the grate. Once in 10-12 min. tend the fire.

13.16 Comparison of the Traditional Stove with the new stove

In order to evaluate the new stove about its utility, a comparison between the old and the new is in order. This is given in Table 6. In over 10 villages of Uttara Kannada, the new stoves are working and the method of construction is found satisfactory. Efficiencies are uniformly above 38 percent. The new bathroom stove has relevance even in cities like Bangalore. A simple modification of the old stove with chimney (Fig. 1d) to the new one is possible which saves 50 percent of the fuel. This has been done in one house in Bangalore (A-43, CIL Colony, Sanjay Nagar, Bangalore-24). The results show that 1 kg. of fuel is sufficient for bath for 4 people which works out to be cheaper than electricity.

From Table 6, we can clearly see the advantages of the new bath room stove. More than 60 percent of fuel can be saved in the villages. More important, any kind of fuel can now be burnt efficiently. In Unchagi and other villages where the stoves are now in use, mainly agricultural residues such as coconut tree products are burnt without smoke and high efficiency.

13.17 Fuel efficient Bagasee burnt 2 Pan jaggery unit

In Uttarak Kannada, even today, liquid jaggery is made by evaporating sugarcane juice using wood as fuel. Availability of wood has decreased drastically due to excessive exploitation of forest and farmers are feeling that jaggery making using wood as fuel is no longer economical. This problem was posed to us in the year 1980. Professor Kumar, Dr. M.S. Hegde, Dr.S.S. Lokras and Prof.K.S.Jagadish have looked into this problem. A 3 pan controlled combustion furnace with bagassee as fuel designed and commissioned at Uchangi, a village in Uttara Kannada in Jan. 1981. Efficiency of this furnace was 60 percent. Now modification of the 3 pan to 2 pan jaggery unit is in practice.

13.18 Community jaggery making units : Present practice

In most village in Karnataka, sugar cane is grown and solid or liquid jaggery is made out of the sugar cane

TABLE - 6 : Comparison between old and new bath room stoves

Details	Old stoves	New stove
a) Materials for construction	Stone/brick, mud chimney (if there is one)	Stone/brick, mud, rice husk, chimney 25 cm x 25 cm cast iron grate, wood box cover
b) Fuel	Wood, twigs, dry leaves, dung cakes	Wood, twigs, dry leaves, dung cakes, coconut husk, areconut husk
c) Comfort	Types A,B,C are smokey only type D emits less smoke	Totally smokeless; easy to light, easy to maintain fire (by fanning through ash removing space)
d) Cost	Cost is due to bricks/stone chimney I(if there is one) and labour	Same as traditional ones except the grate, chimney if it is not there, mud box cover
e) Efficiency	10-22	40
f) Fuel saving	-	Over 60
g) Time for heating	About 60 min to make 50 lit. of water ready for bath	Only 25 min. to make 50 lit. of water ready for bath
g) Cooling rate	About 2° per hour (initial temp. $60^{\circ}C$)	Less than 1° (initial temp. $60^{\circ}C$)
i) Fire hazard	High	Nil

juice by evaporating it in a single or two pan furnaces. In planes of Karnataka s ich as Tumkur, Mandya, Mysore, bagasse is used as fuel where they use two pan furnaces. They make solid joggery. In places where sugar factory is nearby, the surar cane is sold to the sugar factory. It is important to note that jaggery making is a true village industry. Jaggery replaces the costly sugar for a large variety of sweets.

In western Ghat region of Karnataka viz., Uttar Kannada, Dakshina Kannada, Chikamangalur, Shimoga (there is a sugar factory) jaggery is produced by evaporating the juice using wood as fuel. Since the soil is highly acidic, they cannot make solid jaggery; instead they produce liquid jaggery stored in mud pots. Historically, Western Ghat region of Karnataka had the highest forest cover and wood was available in abundance nearer to the sugar cane fields. Therefore, the practice of using wood was common. Due to moisture content in the soil and atmosphere, sugar content in the juice is lower compared to the sugar cane grown in the planes of Karnataka. Even though people of Uttara Kannada tried to use bagasse, it was not sufficient to make jaggery since water content in the juice was more. Present position is such that wood is no longer available and using wood to make jaggery is not economical.

Jaggery making process in villages of Uttar Karnataka and elsewhere is a community venture. Crushers are eracted in a common place nearer the sugar cane fields of most people of that village. The crusher is owned by a farmer not necessarily of that village. The labour for transport of the crusher is shared either by payment or by lending labour by the farming families. Normlly, one person per sugar cane farming family join together and work is carried out on a community basis. During this time they erect the wood burning stove also. Present practice is to use two furnaces at a time independently with wood as fuel. In places where they use oil engine run crushers, sometimes even 3 independent furnaces are put up.

In bullock (or he buffallow) driven crushers, the crushing, process is slow. Sugar cane crushed for one unit is called 'ADIGE'or'ESARU' consisting of 300 litres of juice. Duty of the owner of the crusher is to extract 300 litre of juice, count it as one unit and collect his charge (Rs.14-18 in the year Jan. 1984). Then, the farmer has to make jaggery out of it. Jaggery making oven using wood as fuel is shown in Fig. 12 and that using bagasse is in Fig. 13. They have fuel efficiencies of 20 and 35 percent respectively.

People of Uttar Kannada still use wood to make

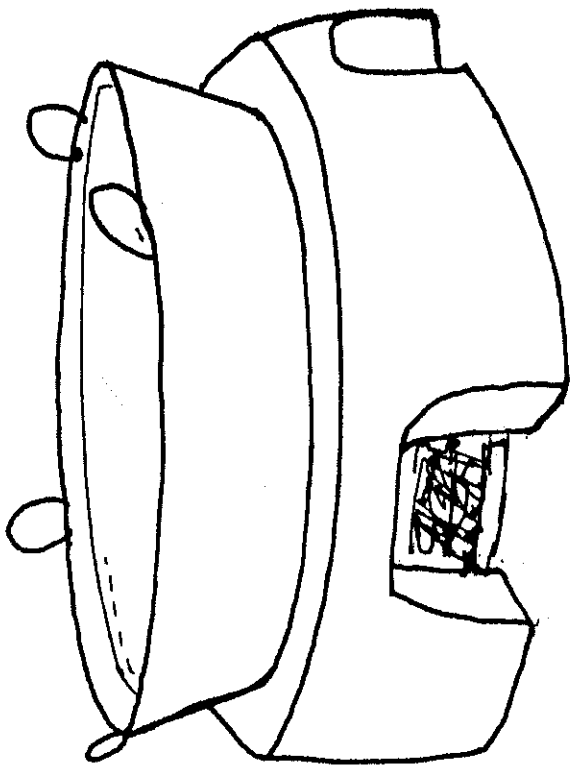


Fig. 12

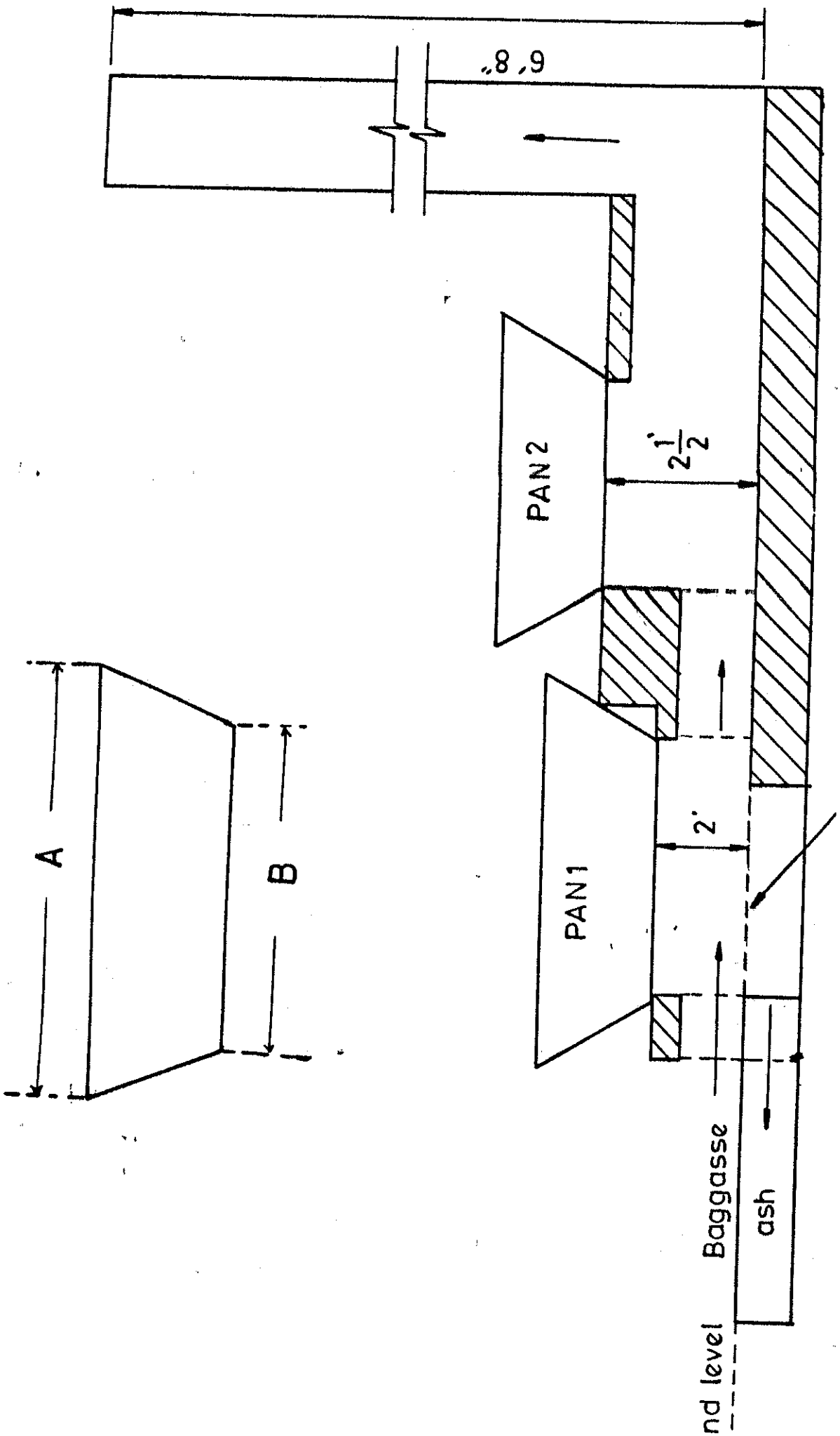


FIG. 13

jaggery. Quality of wood required for making jaggery out of 300 litre of juice (they get 55-60 kg of liquid jaggery) is 200 ± 10 kg. Fuel efficiency of these stoves work out to be very low (< 20 percent). The stoves are difficult to operate due to excess smoke. In summer, heat around the furnace makes it difficult for persons to stand nearby to remove scum (Gobbara) and other operations. Time required to make jaggery out of 300 litre of juice using wood is 5.5 hours to 6.5 hours.

To lift the pan, 4 people are required. Also for cutting the cane, crushing, to transport the wood etc., at least 5-6 people work at a time. Many families may not have this kind of labour force. Therefore, families in the villages depending upon their relations with others, help each other on exchange of labour basis. Thus the processof making jaggery is one of a community venture. By tradition, same place is used every year.

Number of unit evaporated a day depends on whether the crusher is bullock driven or oil engine run. In bullock driven crushers, a maximum of 4 units can be crushed a day with one pair of bullocks whereas in oil engine run crushers at least 8 units are crushed a day. The practice is that the owner of the crusher provides mild steel pans and all accessories for making jaggery; only the labour and fuel comes from the farmers.

13.19 Two pan Bagasse fuelled community jaggery unit : New method

In this section, principle of the new 2 pan jaggery making unit with bagasse as fuel is described. In order that the new method becomes easily acceptable, the following criteria in the design are imposed:

(a) The local people must be able to fabricate, operate and reapir the unit

(b) Locally available materials be used in the construction of the furnace.

(c) Existing mild steel pan and all the accessories (supplied by crusher owner) be adopted in the new furnace.

Pan size, dry bagasse per 300 litre of juice etc., are given below:

Pan size	Bottom diameter	48 to 55 ins.
	Top diameter	60 to 72 ins.
	Height	12 to 14 ins.
Volume of juice per unit		300 litre
Volume of jaggery (per unit)		40 to 50 lit
Weight of jaggery		55 to 60 kg.
Number of units crushed per day		6
Weight of dry bagasse per unit (varies with the quality of sugarcane)		90 to 105 kg
Calorific value of dry bagasse		4444KCal/kg.

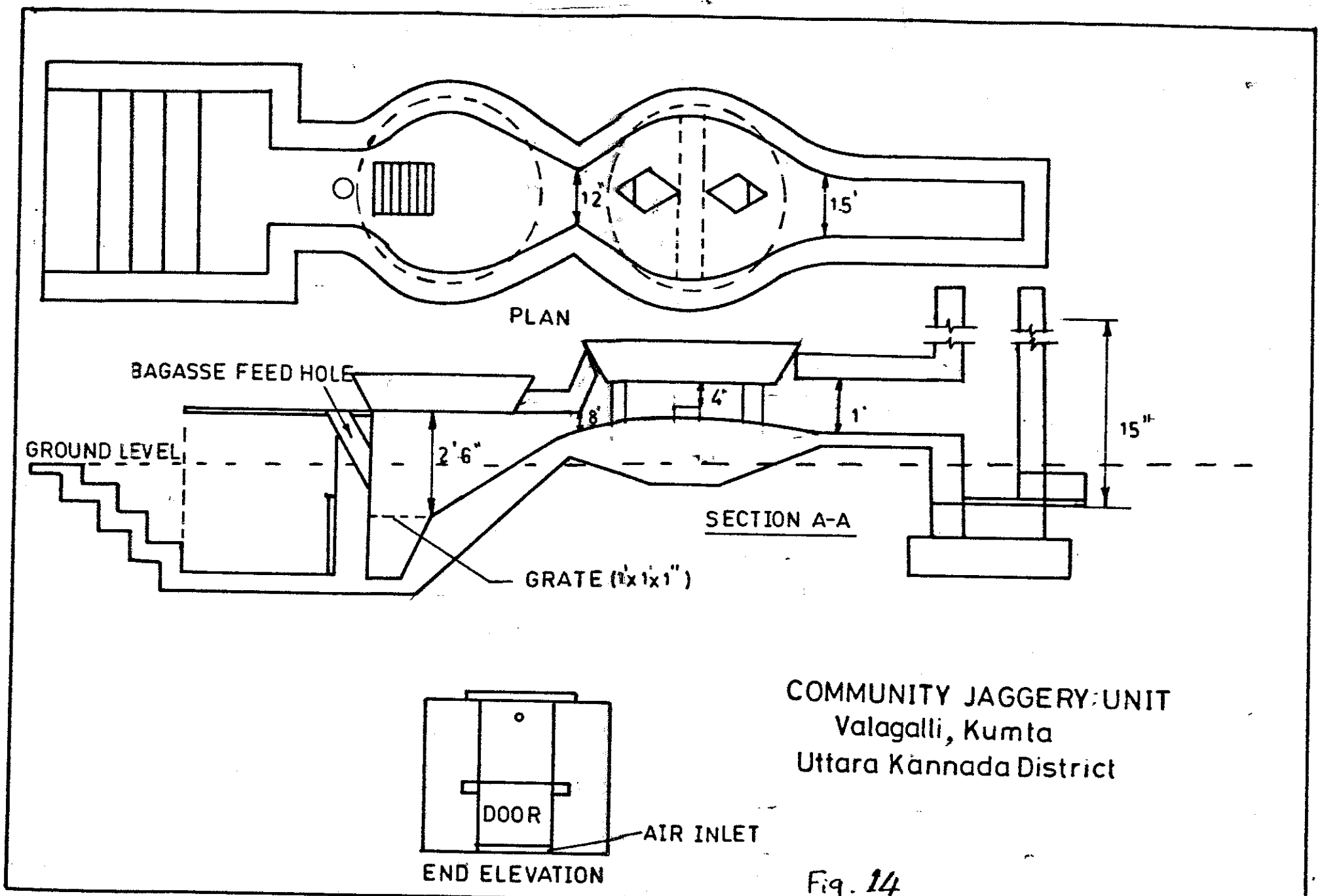
When 1 kg of dry bagasse is burnt, 4444 KCal of heat is generated. This much heat is generated provided the fuel is mixed well with only the required quantity of air. This is achieved by burning the bagasse on a cast iron grate. Cast iron can withstand higher temperature and it does not bend even when heated to 1000-1100°C. Therefore cast iron grate is used. The required amount of air is allowed through the grate. When the bagasse is burnt, water vapour, carbon dioxide are produced in addition to small quantity of organic volatiles which are not burnt. Provision of space above the fuel has to be made for occupying these gases. This is called combustion volume. Hot gas that is generated form the flue gas. This is now allowed to pass through below the second pan and then finally through a chimney. The design is shown in Fig. 14.

The first pan receives heat due to radiation as well as convection of hot gases and the second pan largely receives heat due to convection of the flue gas.

Considering that about 4 hours are required for making jaggery from 300 litre of juice, only 20 kg of bagasse is to be burnt per hour. Generally, about 20 kg of bagasse can be burnt over 1 ft x 1 ft area of the grate. Therefore grate size is fixed at 1 ft x 1 ft. Since we employ only two pans, maximum heat generated

is utilized by the first pan and smaller quantity of heat is utilized in the second pan. That is why the duct area (window between the first and second pan) is kept small namely, 12in x 8in. In order that the second pan heats fully, the 3/4 of the pan is dipped so that maximum surface area is available for heat transfer. 12 in x 12 in x 15 ft. high chimney is provided to see that flue gas goes out without causing any backfiring of the fuel. No gas is allowed to pass through the wall or the edge between the furnace and the pans.

With these requirements, the new furnace that has been designed and working in several places in Uttara Kannada (see Fig. 14). The diagram shows that air is allowed below the grate and it is controlled by a window. Bagasse is fed above the grate via a 4 in diameter feed hole. The distance between the grate and pan bottom is 2 ft 6 in. The flue gas passes through the second pan and then through the chimney. The first pan is not dipped. This is because, due to excess heat below the first pan, jaggery gets charred and the colour gets red. The first pan sit on the furnace. However the second pan is dipped so that atleast 3/4th of the wall of the pan is inside the furnace. The second pan can be supported from bottom through narrow pillers. The sides of the first as well as the second pan are covered with mud. The distance between the second pan and the furnace



COMMUNITY JAGGERY UNIT
Valagalli, Kumta
Uttara Kannada District

Fig. 14

13.54

is only 4 in. Due to this the second pan boils easily. When the furnace is operating properly, 18-20 kg. of bagasse needs to be fed per hour. Temperature below the first pan is as high as 850°C; below the second pan it is about 450°C and in the chimney it is about 250°C.

This furnace is now compared with the bagasse burnt furnaces in Mandya and other cases. The changes are in the use of a cast iron grate and method of bagasse feeding. The distances between the pan and the grate, is 2 ft. 6 in. Distance between the bottom of the second pan and the base of the second furnace is only 4 in. These distances are adjusted through extensive experimentation so that over 52 percent of the heat generated is utilised for heating the pans. Air inlet is controlled through a door below the grate.

13.20 Materials for Construction of the New 2 Pan Furnace

In Uttara Kannada, Dakshina Kannada, lattrite stone of 15 in x 9 in x 9 in is commonly available. In other areas bricks (even umburnt) can be used. Quantity of the materials required are given below:

(a) Lattrite stone	500, if bricks 2,500
(b) Cast iron grate	15 in x 12 in x 1 in One No.

(c) Window for air inlet out of GI sheet (16-20 gauge)	18 in x 11 in area
(d) Measuring tape, lime for marking	
(e) Sand, sieved mud	for construction of walls
(f) Cement about 5 kg	to make bagasse feed hole
(g) Mild steel pans	to be supplied by owner of the crusher - 2 Nos.
(h) 1 in hose pipe	to siphen juice

Masons who can construct the stone wall or brick wall can easily construct the furnace provided measurements are told by a trained person. Approximate cost of materials is about Rs.1000 as per the price prevalent in the year 1984 and then the labour charges for mason, clearing the site, guidance for construction is about Rs.1000/-. At the present rate about Rs.2000/- required to install one unit.

13.21 Construction of the new furnace

With the experience gained in constructing the several furnace in places, the following procedure is found satisfactory. Select a place for the unit which is close to the sutarcane fields of most of the farmers. If it is near to the road, it is better for easy transport. It should be a common place. This place will be used every year since the furnace constructed will last several years which costs about Rs.2000/- .

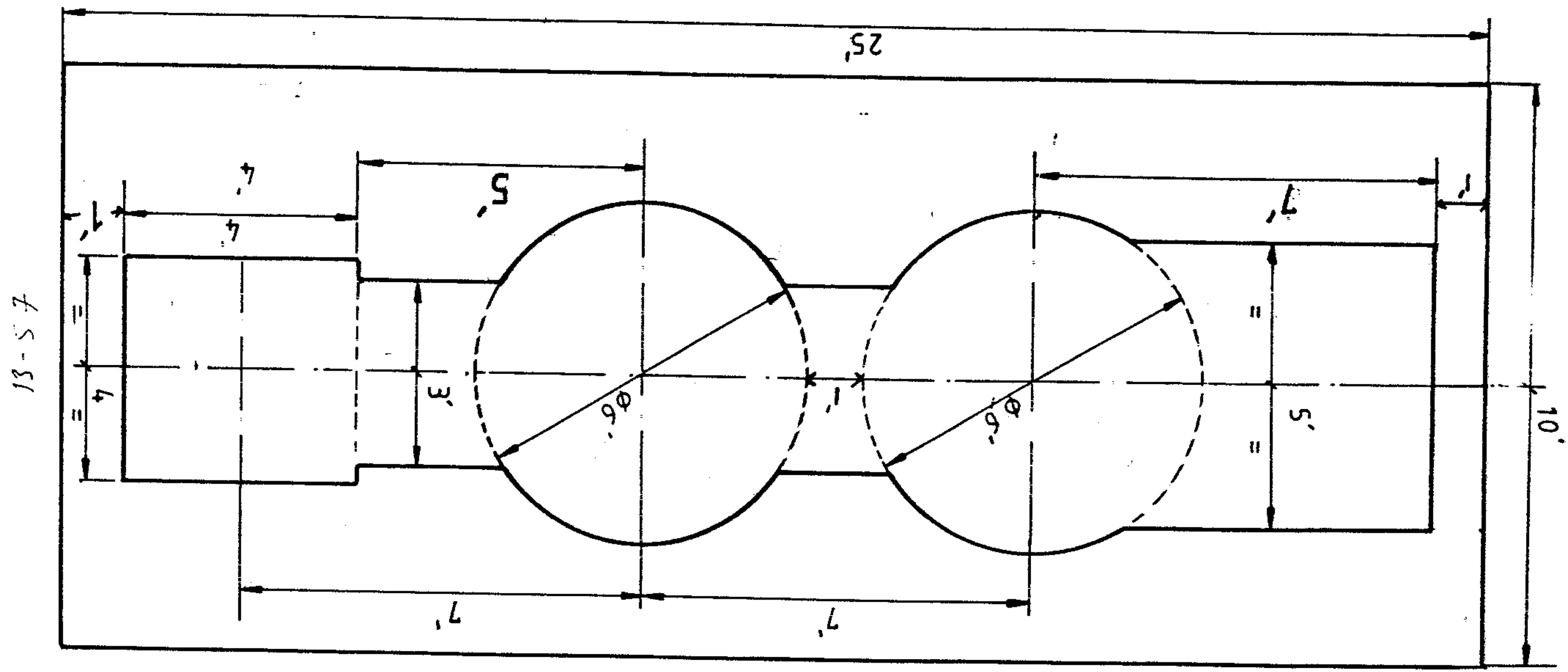


Fig. 15

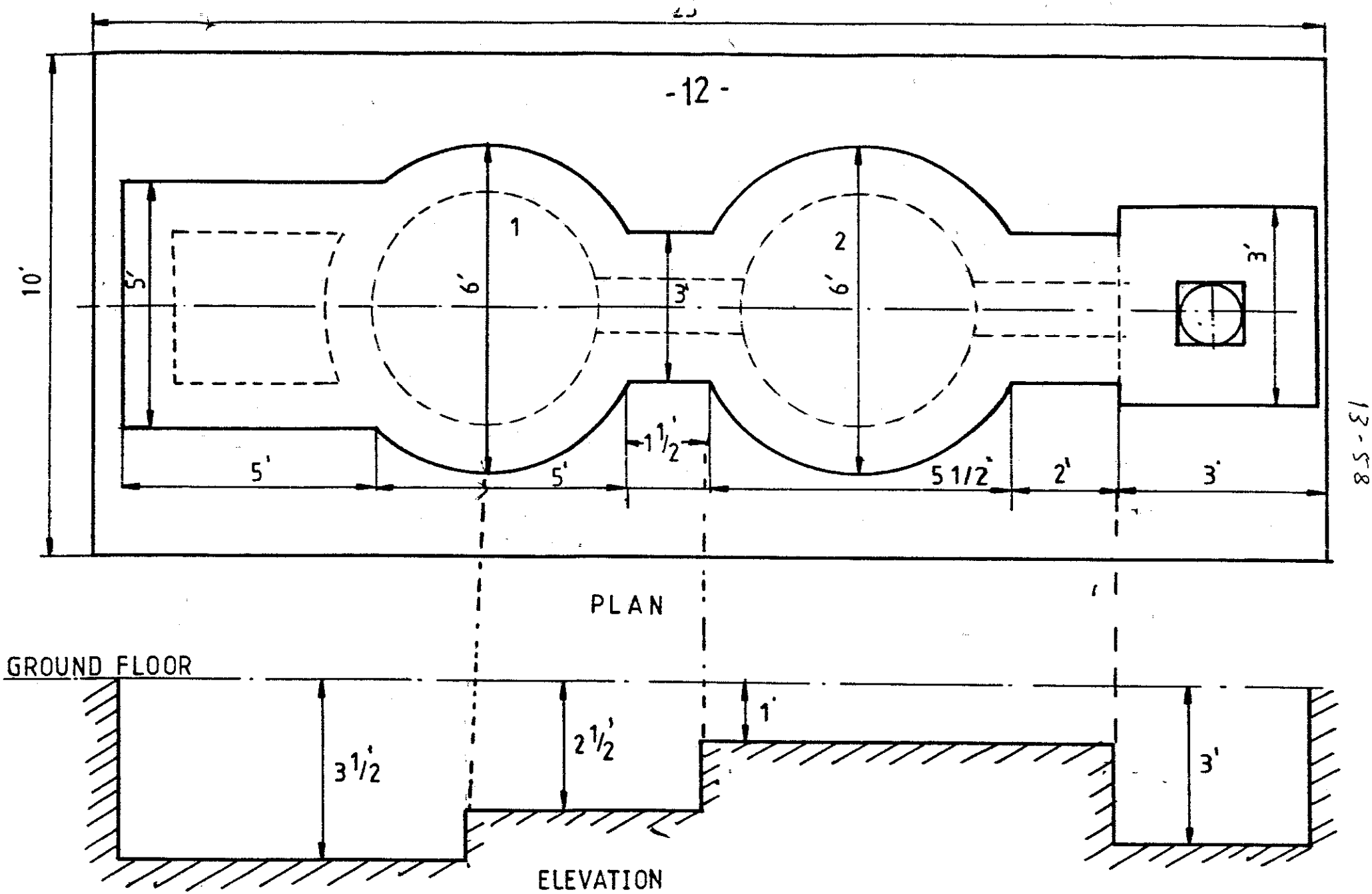
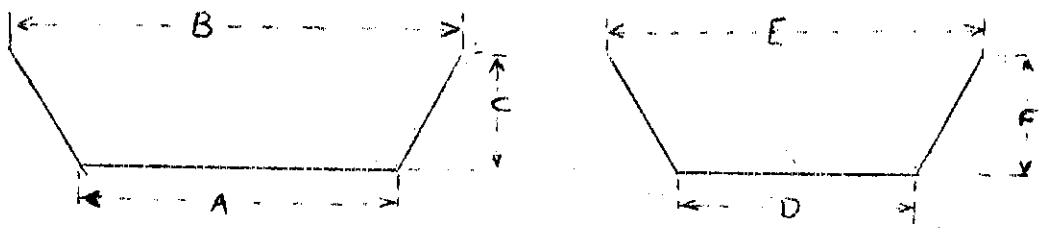

10'
5'
1
6'
3'
2
6'
3'
3'
5'
5'
1 1/2'
5 1/2'
2'
3'
PLAN
GROUND FLOOR
3 1/2'
2 1/2'
1'
3'
ELEVATION

Fig. 16

Steps for construction are given below:

1. Mark the areas of 25 ft x 10 ft as shown in Fig. 15. Then depending upon the area, at one end of this plot along the length, chimney will be constructed and at other end, first pan is placed. Decide the direction.

2. Measure the dimensions of the pan as follows:



(a) Bottom diameter of the first pan = A =

(b) Top diameter of the first pan = B =

(c) Height of the first pan = C =

(d) Bottom diameter of the second pan= D =

(e) Top diameter of the second pan = D =

(f) Height of the second pan = F =

To describe the method of construction here in this manual, top diameter of the first as well as second pan is taken as 6 ft (72 in) and bottom diameter as 4.5 ft. (54 in).

3. Draw central line of the plot 25 ft x 10 ft along the length. Leave 1 ft from one end along the central

line (start from the opposite end of the chimney). Measure 7 ft from this point and mark it. Draw a circle of 6 ft diameter with this mark as the centre. Considering that 6 ft is the top diameter of the first pan this would be the place where the first pan sits finally. Mark the centre of the second pan and draw the circle such that distance between the circumference of the first and the second circle is 1 ft. Leave 2 ft from the end of the second circle and mark 4 ft x 4 ft square for chimney. Leave 2.5 ft either side and join the first line and the first circle. Leaving 1.5 ft. from the centre line, join first and second circles, leaving 1.5 ft either side from the central line join the second circle and chimney. All these markings are shown in Fig.15. This now forms digging area for foundation.

4. Dig out mud upto 3.5 ft. depth from the first end till the centre of the first circle along the marked portion. From the centre of the first circle to beginning of the second circle, dig out only 2.5 ft depth; from this point to the beginning of the chimney, dig out only upto 1 ft depth; finally below the 4 ft x 4 ft chimney area, dig 3 ft for foundation of the chimney. This is shown in Fig. 16. Isometric view after the place is dug is shown in Fig. 17. Now mark the central line inside the pit along the length and also mark the centres of the first circle as well as the second circle.

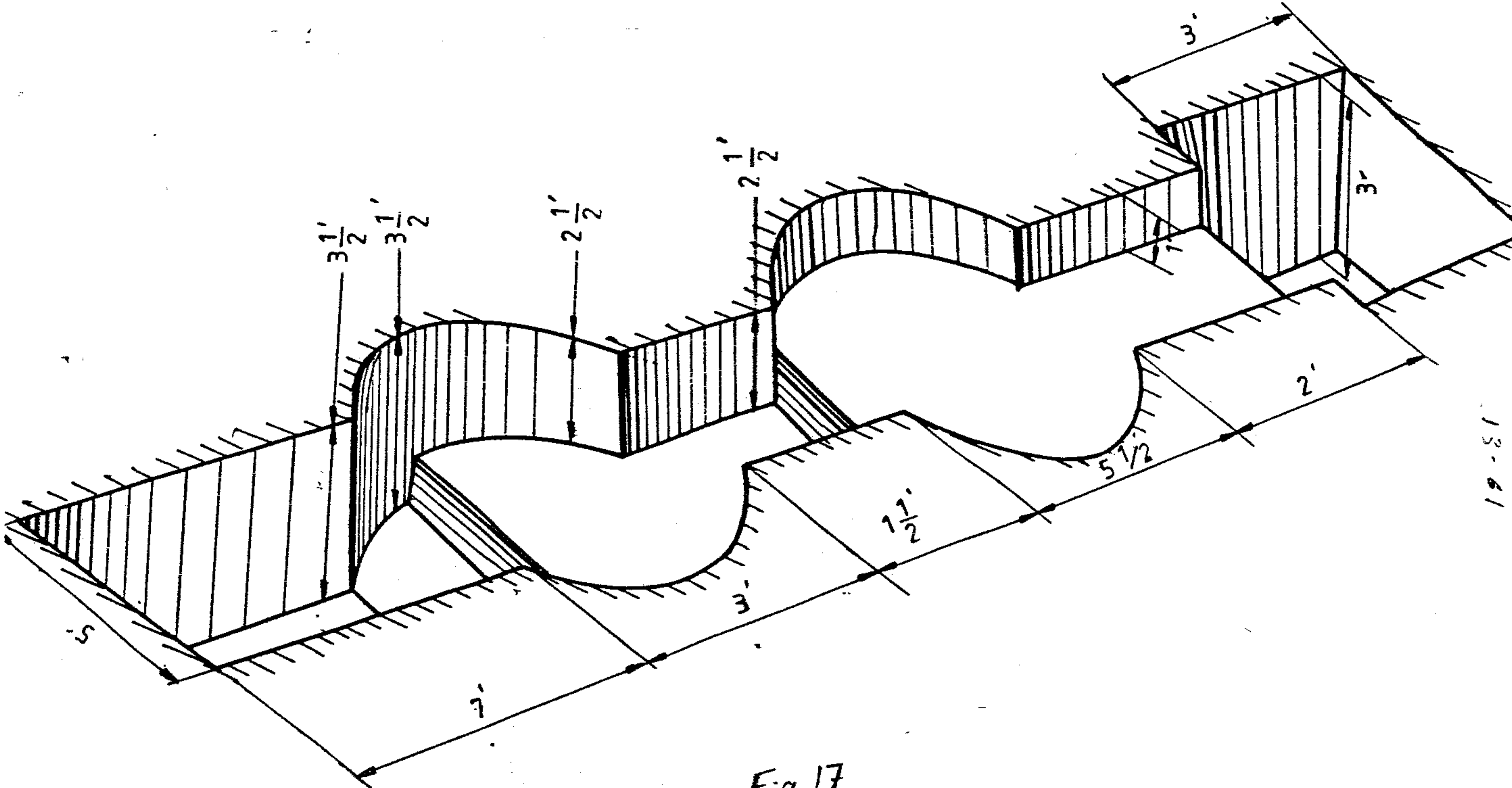


Fig. 17

13-61

5. To place the grate, construct 1 ft high walls with about 9-12 in thickness leaving 1 ft gap between along the central line. This should beconstructed in the 3.5 ft deep pit from the centre of the first circle. The length of the wall will be 3 ft. Keep the 15 x 12 in grate on this rectangular 3 ft channel at the centre leaving 12 in either side. Fill up by a stone of 1 ft at the centre side. This is dhown in Figs. 18 and 19.

6. Construct the wall of the first furnace in circuler well shape with its inside diameter equal to the bottom diameter of the first pan. Leave a gap of 12 x 12 in below the grate for removing the ash as well as for letting air for combustion. Thickness of the wall can be 9 in to 12 in. If there is any gap between the outside wall of the furnace and the ground, it can now be covered with mud just as is done for a regular well.

7. After the first two layers of stone in the 3.5 ft deep ground, the construction starts on the 2.5 ft deep ground. After constructing about 1 ft high wall over 2.5 deep ground, leave 1 ft gap between the two ends of two circles and continue the construction all the way to chimney. Good foundation should be given at the base of the chimney leaving 1 ft x 1 ft inside area.

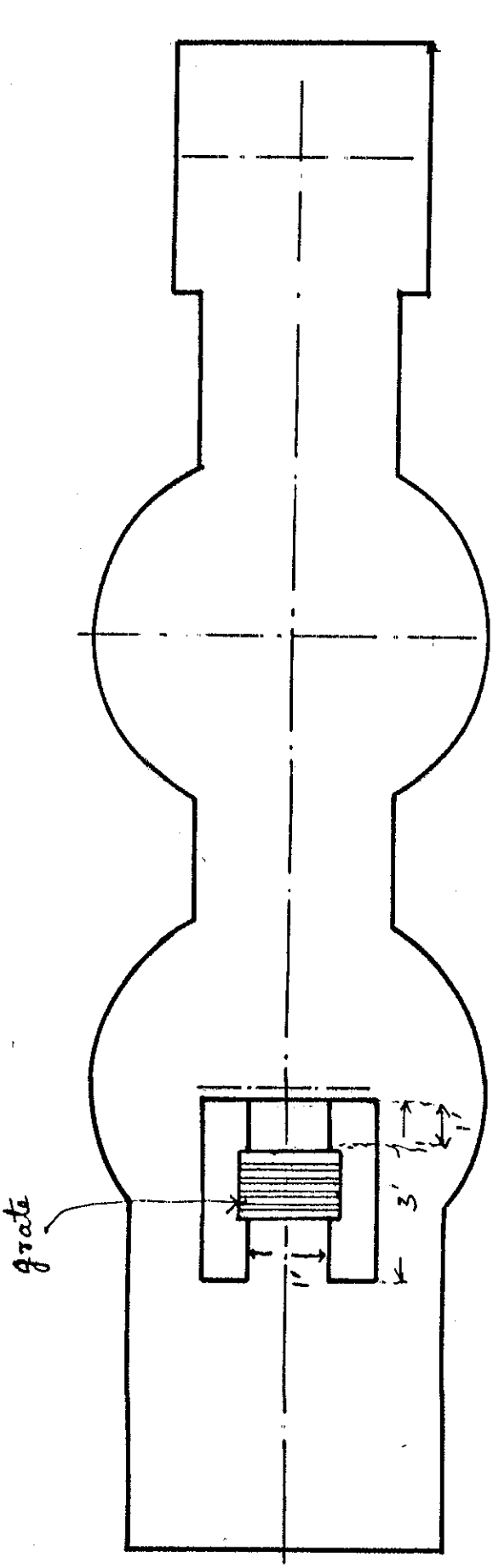
8. In the first pan side, construct the walls on both sides with 2 ft gap between. On the wall above the air

inlet, a 5 in diameter baggasse feed hole be carved out in the stone such that by the time the full wall is constructed, the bagasse fed from the hole outside should fall on the grate. The 5 in diameter hole is at an angle. This is shown in Fig. 20.

9. Construct the first furnace to a height of 2.5 ft from the grate. Now keep the pan on the first furnace. It should nugdly sit on the furnace. Mark the level at which bottom of the pan sits. Height from the grate to this mark should be 2.5 ft. If the height is less, increase the wall height; if it is more reduce the wall height.

10. The bridge between the first and second pan can now be constructed in the form of an arch out of bricks or by using a long lattrite stone. Now raise the height of the second furnace. While doing this, increase the diameter of the furnace so that atleast $3/4^{th}$ of the second pan can be dipped in the furnace. Keep the second pan on the furnace. The bottom level of the second pan should be at the top level of the first pan. This is for easy transfer of juice from second pan to the first pan by siphoning. If the height of the second furnace is not sufficient, increase it further.

When the pans are kept on the furnaces, distance between the pans should be about 12 in. If it is more,



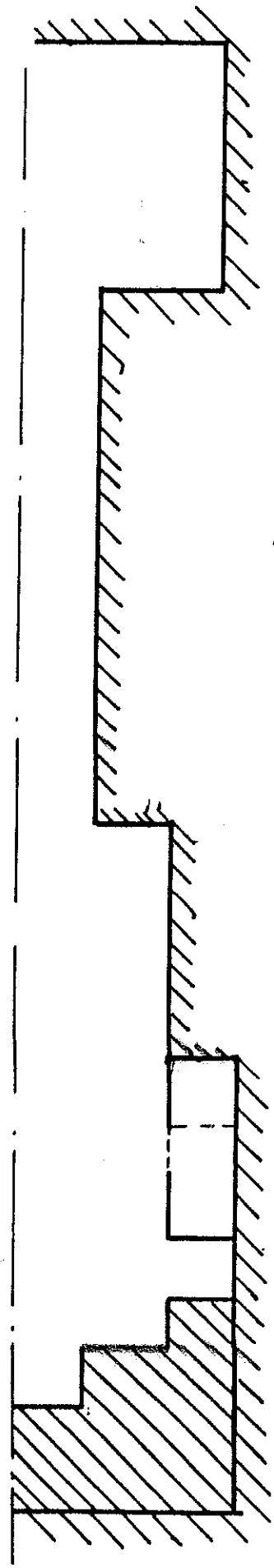


Fig. 18

13-66

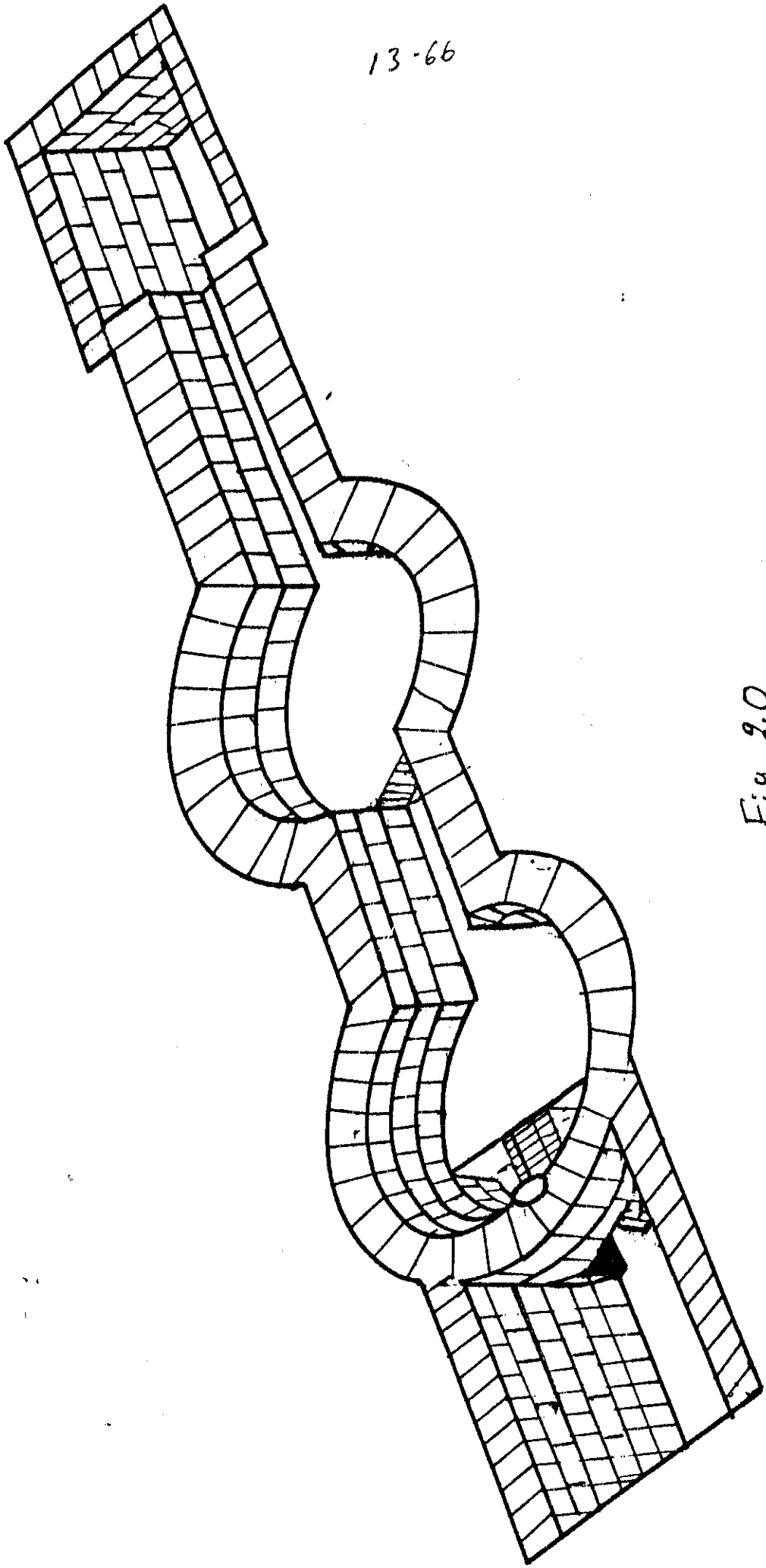


Fig. 20

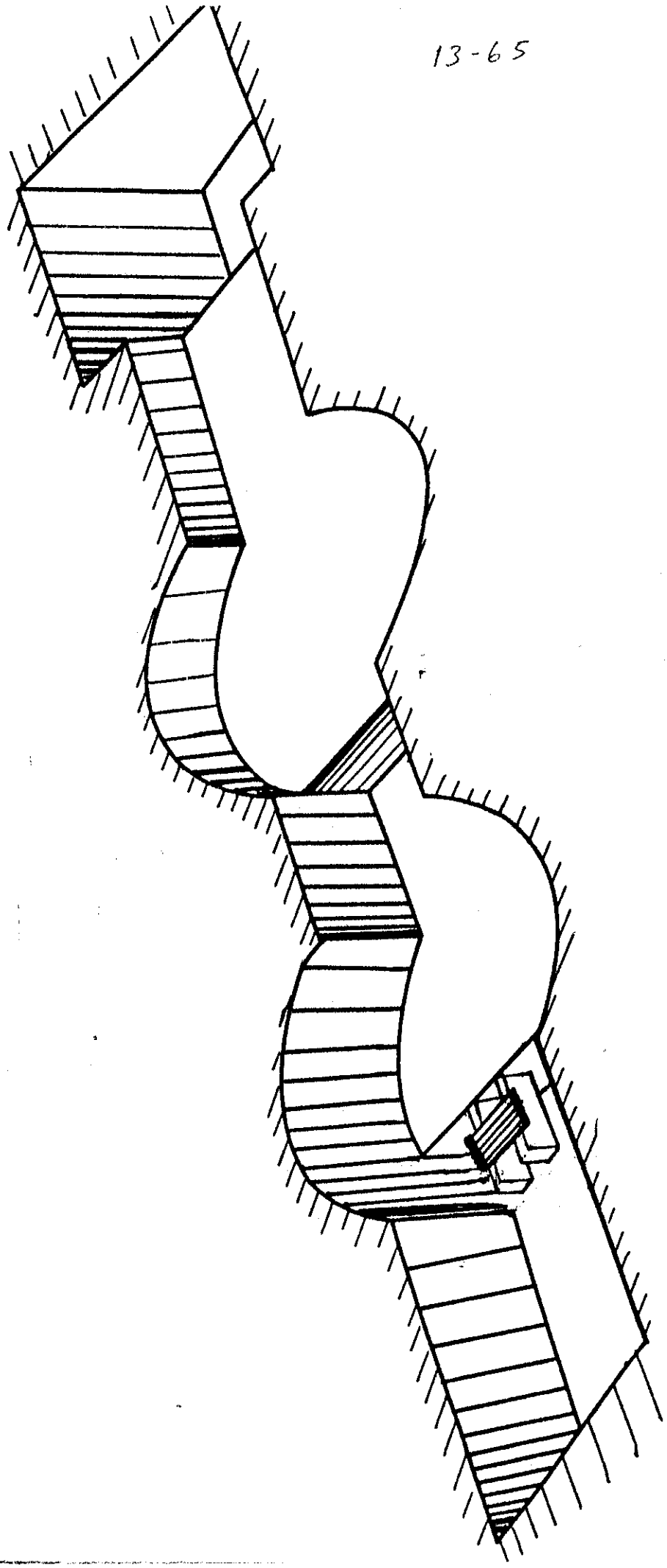


Fig. 19

scrape the wall of the second furnace and bring the second pan closer.

11. There is now a window between the two furnaces. This is called DUCT . Fill up the mud in the first furnace from the end of the grate till the DUCT such that the DUCT size is kept 12 in. wide and 8 in height. Below the bridge between pans put mud to achieve this. Shape the bottom of the first furnace such that the flame going out from the first furnace to the second furnace is directed towards the bottom of the second pan. This is shown in Fig. 14 as well as in Fig. 21.

12. Construct a bund across the centre of the second furnace (below the pan). The height of the bund should be such that the distance between the bund top and the bottom of the pan should be only 4 in. This bund helps the hot flue gas to hit the pan and heats the juice in the second pan faster.

13. Make sure that there is sufficient gap between the stone wall and the side of the second pan when $3/4^{th}$ of it is dipped. Only when there is a gap, hot air circulates around it and heats the sugarcane juice in the second pan properly. In case the pan is not strong enough, pillers in the bottom of the second pan can be given to support it.

14. Cover the channel between the second furnace and the chimney making sure that atleast 12 in x 12 in area is there throughout the length of the channel for fluegas passage.

15. Dump mud in 3 ft chimney pit upto 2 ft. height. Then on, construct 15 ft high chimney with 12 x 12 in inside dimension. Make sure that chimney is strong by keeping bottom dimension wider. Flue gas from the second furnace is let into the chimhey with 12 in x 12 in clearance.

16. Construct the steps to go down to ash removing place. Provide a 18 in x 11 in door made of a tin sheet to the air inlet hole of 12 in x 12 in so that 12 in x 1 in gap will be left for air inlet. This is how only controlled amount of air is supplied through the grate to the bagasse for proper burning.

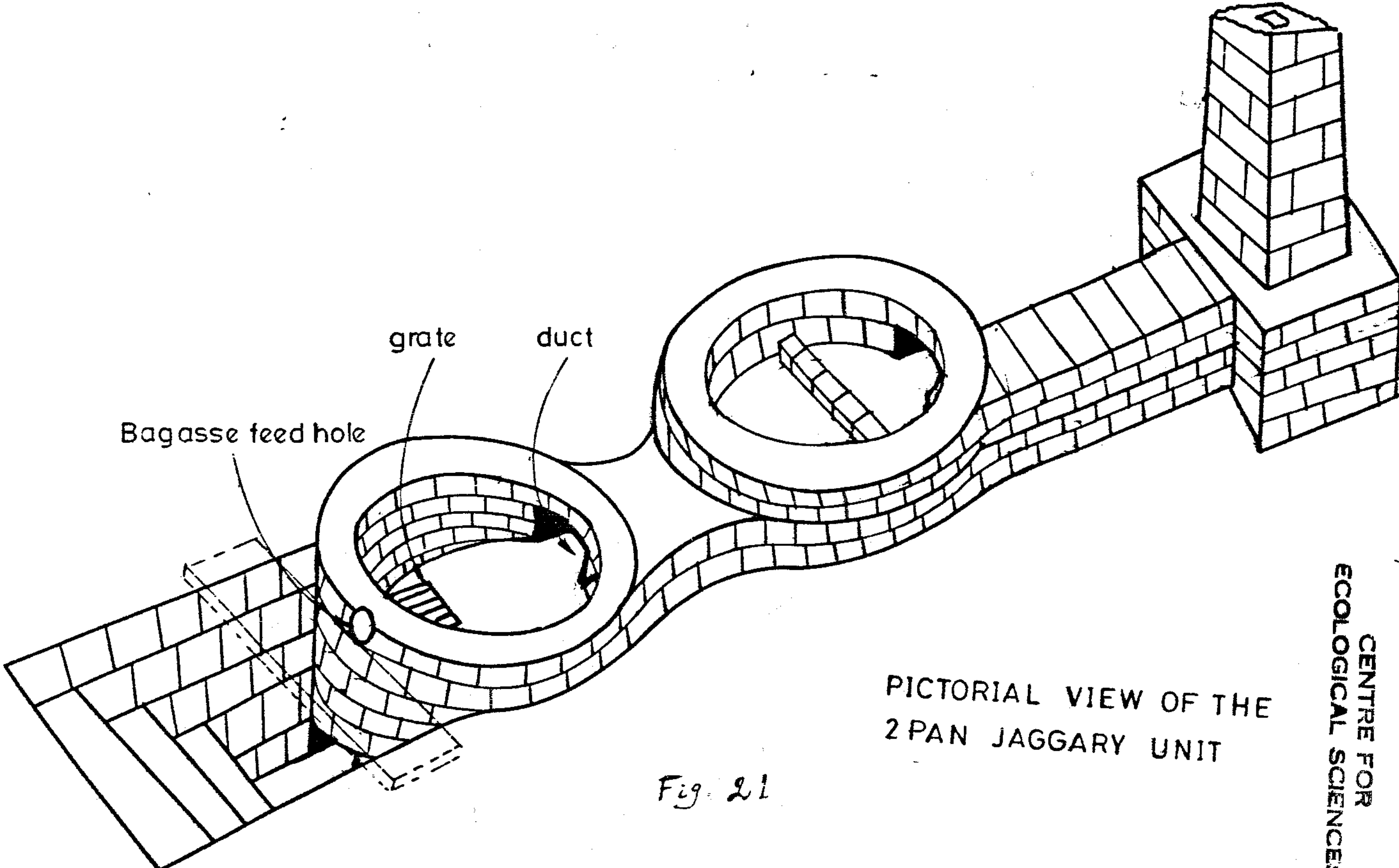
17. Keep some wooden planks across the two feet channel on the side of the baggassee feed hole. A man can sit on it and feed baggasse.

18. Figure 21 shows how the jaggery unit looks finally. Check for the following dimensions once again.

(a) Air gap below the grate = 12 in x 1 in

(b) Distance between the first pan and grate = 2.5 ft.

(c) Distance between the first and second pan = 12 in.



PICTORIAL VIEW OF THE
2 PAN JAGGARY UNIT

Fig. 21

(d) Height of the second pan from the first pan = 12 in

(e) Distance between the second pan and the bund top = 4 in

(f) There should be a slope from the grate and the DUCT

(g) Duct size between the pans = 12 in x 8 in

(h) Duct size between chimney and second pan = 12 in x 12 in

(i) Grate area = 12 in x 12 in

19. Plaster the jaggery unit with cowdung and mud so that no flue gas leaks through the wall; put wet mud at the odge of the pan and the furnace if there are holes.

How to operate the Furnace?

1. Fill one unit of juice (300 litres) in each pan. Put the fire through the bagasse feed hole. Initially the fire comes back through the hole. Take a sugarcane and push the burning bagasse on to the grate and feed more bagasse. Suddenly, the flame stops coming out through the hole; direction of the flame is towards the second pan; smoke appears at the top of the chimney. Now the furnace is set for evaporation of the juice.

Rate of Bagasse Feeding:

Make sure that the bagasse is sun dried atleast for two days. While feeding the bgassee watch the color of the flue gas coming out of the chimney. It should not

be too dark. This means feeding is more. The smoke should bot be too light. This means feeding rate is less. The color of the flue gas should be slightly dark. About 18-20 kg of dry begasse per hour should be feed.

Control of Flame:

The first pan comes to boiling in about 35 minutes. Just before the boiling point is reached, the scum (Gobbara) sets in. Fuel feeding can now be reduced till the scum is completely removed. After this, boiling can be continued. When the froth comes up, feeding again can be reduced. During this period, second pan also comes to boiling and scum can be recovered. The first pan matures in about 4 hours. Remove the first pan and empty the jaggery. Put the pan back on the furnace and transfer the juice from the second pan in which 1/4 of juice is already evaporated. Fill the fresh juice (300 litres) in the second pan and continue the operation. This time jaggery matures in 3 hours. The fomplete working operation is shown in Fig. 22.

ADVANTAGES OF THE NEW COMMUNITY JAGGERY UNIT

The farmers who are accustomed to burning wood find the new community jaggery unit somewhat combersome initially. The factors for this are:

(a) They are not used to burn bagasse

(b) They feel that one person should continuously feed.

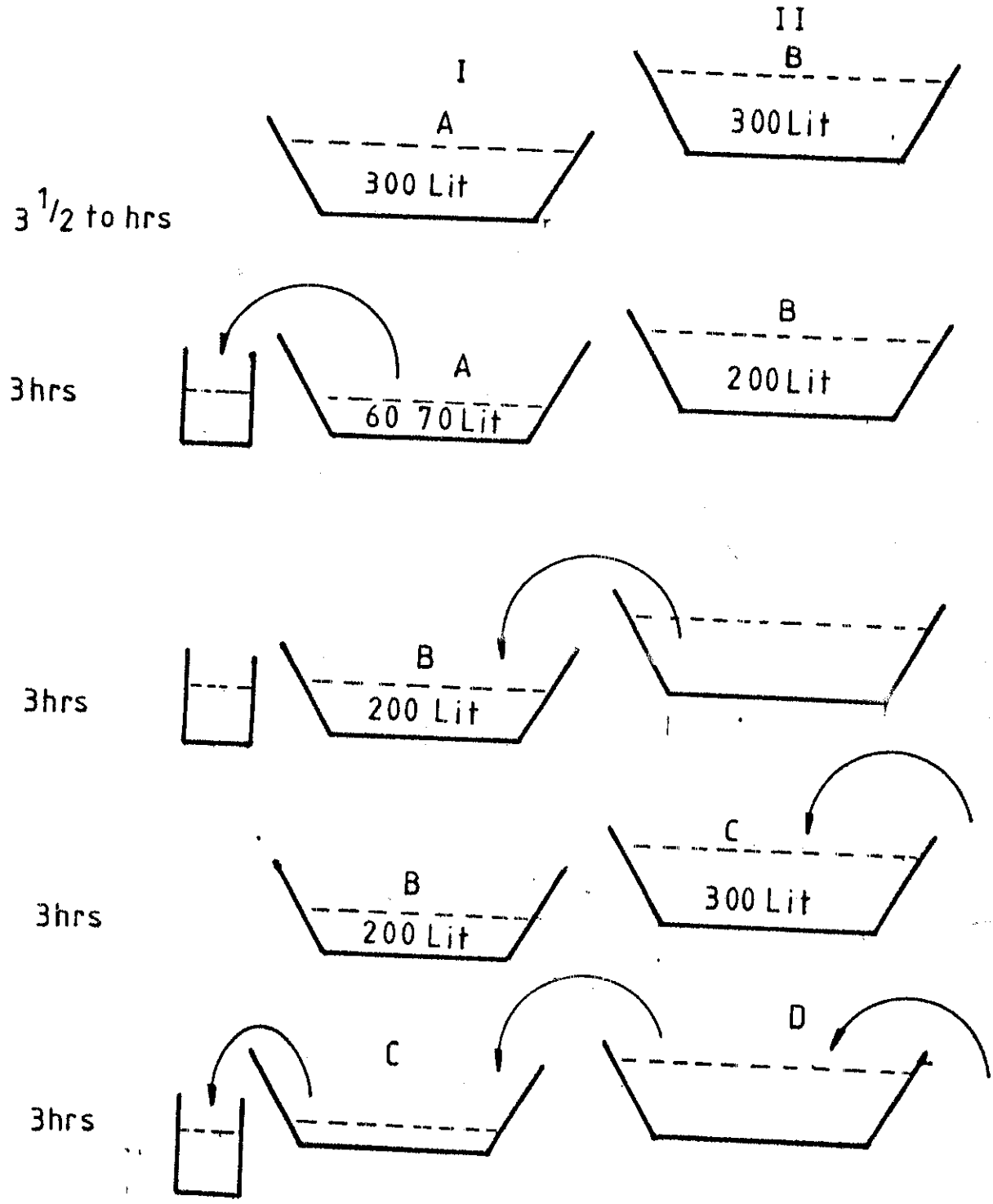

I
II
A
B
300 Lit
300 Lit
3 1/2 to hrs
3hrs
A
B
60 70 Lit
200 Lit
3hrs
B
200 Lit
3hrs
B
200 Lit
C
300 Lit
3hrs
C
D

Fig. 22

Once the farmers get used to the new furnace, special advantages given bellw become obvious.

- Bagasse burns very nicely in the furnace; very little ash collection is found;
- No smoke at all around the pan and no heat while working around the pan ;
- No heat near the bagasse feed hole;
- Fire can be controlled instantly by stopping feeding bagasse;
- Over flowing of the juice during the frothing stage can be completely avoided;
- Wood is totally saved ; if carefully operated 20-25 percent of the bagasse produced can be saved ;
- Complete safety from fire hazards is achieved since flame is totally enclosed ; there is no chance of bagasse or jaggery catching fire.
- Heat transfer efficiency in wood burnt single pan stove is 20 percent; presently used 2 pan bagasse burnt jaggery unit is 35-40 percent.

This new furnace has 52 percent effifiency. Therefore the new furnace sawes all the wood and more bagasse.

13.22 Fuel conservation - its role in Ecodevelopment

In the last few sections, a detailed account of (a) fuel efficient cook stove viz. ASTRA OLE, (b) fuel efficient bath room stove and (c) fuel efficient jaggery unit have been given. It is self evident that over 50 percent of fuel can be saved in the first two devices and in the community jaggery unit 100 percent wood is

saved. This essentially means that one year's fuel is sufficient for two years provided care is taken to build the stoves as per the design.

Our experience in Uttara Kannada is that the cut wood is slowly being replaced by twigs, husks etc. and to that extent, cutting of trees for fuel needs is reduced. This is in addition to the saving cut wood itself by burning it efficiently. Bath room stove is also becoming popular since any kind of fuel can be burnt in it. This design can be used to boil raw areca, perboiling rice and so on.

Jaggery unit designed here is extremely useful now because wood is totally eliminated. If this technology is spread in every village, in Uttara Kannada alone, 30,000 tons of wood (in the form of logs) can be saved in one year.

Therefore, saving of fuel as well as replacing costly cutwood by agricultural residue has made a significant impact on the farmers in Uttara Kannada. Farmers are now taking to these new stoves. Individual farmers are feeling the special advantages of these new devices. To make an impact on the total vegetation growth or reduction in cutting rate of forest, atleast 80 percent of the families should adopt these new technologies. There is a constant effort by the Govt. of Karnataka, and the voluntary organisations to achieve this goal.

14. HABITAT

14.1 Resource Needs

Shelter, a basic need of human beings makes several demands on natural resources. Its construction requires earth, stone, wood and leafy material, as also metals, cement, bricks and tiles which not only demand material but large quantities of energy in their production. There is much scope for increasing the efficiency in the use of these materials and of energy in their production.

Human habitats also need not only the heat energy considered in the last chapter; but also water and a system of disposal of waste water, systems of roads and bridges for transport and means of communication. We can also improve upon resource use in these contexts as well.

14.2 Action Points

(i) Enhancing the availability of structural materials such as poles and bamboos

(ii) Reducing the need for thatching material by rendering the thatched roofs more resistant to fire and decomposition

(iii) Dispensing with the need to fire bricks by using soil compaction devices such as ASTRAM

(iv) Adapting traditional methods of efficient resource use in making house flooring etc.

(v) Construction of cheap and efficient latrines such as Sulabha Shouchalaya

(vi) Efficient use of energy in habitats other than discussed in the 13th chapter such as solar water heating for bathing.

(vii) Providing efficient means of transport without making excessive demands on resources by examining the present road construction practices etc.

15. AGENTS OF DEVELOPMENT

15.1 Social context

The Indian society is a very complex, inequitous, hierarchical organization, and its nature must be understood and taken into account in planning for eco-development action. This means that we must understand the limitations as well potential of each of the components that must be involved in such change. These components would include:

(i) People in the villages divided into caste groups, into landed and landless and with their own vested interests.

(ii) Village Panchayats often dominated by some small powerful groups, but nevertheless the elementary political organization that has to be dealt with

(iii) Yuvak and mahila mandalis in the villages

(iv) Public institutions such as temples or churches

(v) Schools in villages, often poorly equipped with a teacher more often than absent

(vi) Colleges in towns and cities with their National Service Scheme Units, National cadet corps etc.

(vii) University departments and scientific institutions, largely quite ignorant of the real problems in the countryside.

(viii) Agricultural Universities with some good extension programmes

(ix) Field level officers of revenue, rural development, forest, agriculture, animal husbandry and veterinary services, public works, irrigation and other departments

(x) Higher echelons of Government departments and politicians.

(xi) Voluntary agencies.

15.2 Need to work together

The real need is for all these components of the society to work together, in spite of limitations of each one. The Government has many schemes, often excellent. The information about these needs to be properly collated ane widely disseminated. The fuller edition of this manual would have to contain a good account of all such schemes. There is also much technical know how. This will have to be brought together along with names and addresses of institutions and individuals likely to be of help. Then there are a number of excellent voluntary workers and organizations that will have to be brought in touch. Finally, models will have to be tried out of how local people, Govt. officials, voluntary agencies and technical, scientific and educational institutions can all work fruitfully together towards the challenging task of ecodevelopment.