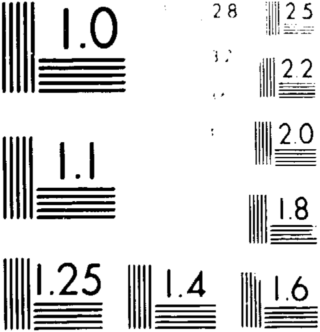
UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org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CASE STUDY

MINI-HYDEL DEVELOPMENT PROGRAM IN NEPAL*

by

P.P. Adhikari**

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** Project Chief, Small Hydel Development Board, Kathmandu, Nepal.

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Preface

Mini-hydel Project Development fail in the domain of regional planning in the policy of His Majesty's Government. In this context such an devlopment is inter-related with in other regional development plans. An assessment of potentials in the regional sector is the guiding factor in any planning and implementation aspect. This paper on Mini-Hydel Project Development assesses all regional as well as national potential and developes the idea of how micro-hydel project could contribute in the overall development of Nepal. It is based mainly on findings, experience of feasibility studies, implementation work in the framework of Small Hydel Development Program being undertaken by HMG.

This paper intends to make the readers aware of the general hydro-meteorological condition of the country - ecological situation in the hills its conditions, potentials, constraints and present development strategy - constraints in development of Mini-hydel Project in remote area with harsh natural conditions - mini-hydel project general economy, appraised of works - selection criteria - necessary tools - alternatives energy resources - pricing of electricity etc.

It is hoped that with this paper the reader could objectively assess mini-hydel project development potential and suggest further imporovement as well as expansion in the present infra-structure.

The auther is grateful to many members of Small Hydel Development Board, to the SATA experts working with SHDB, to the various organisations and authers whose papers, books and articles have been freely referred to and quoted during its compilation.

Outline of Hydrological Resources of the Country.

1. Geography.

Nepal is a country with rich traditions. It is situated in the southern flank of the great Himalayas and is bordered by India in the South, West and East and by Tebetan Autonomous Region of China in the North. The total land area is 1,41,577 square kilometer with a population of about 12 million and population density of about 85 per square kilometer. It lies between 26° 18'-30° 30' N latitude and 80° 15' - 88° 15' E longitude. It is about 900 km. East to West and 140 to 240 km North to South. It has 4 development regions and 75 districts.

2. Geo-physical characteristics.

2.1. Geology.

Nepal is tectonically situated in the southern flank of the Himalayan anticlinorium which is bordered by the Ganges Basin to the South. Like in other parts of the Himalayas, it include two important structural feature - the main boundary thrust and the Central Himalayan thrust. The main boundary thrust separates the siwalik represented by clay, shale, sand-stone, pebble and boulders of middle Miocene to lower plistocene period from the older tertiary and Pre-tertiary rocks. The pre-tertiary rocks mainly unfeasiliferrous include phyllite, quartsite, limestone, dolomite of later protozoic to upper paleozoic period. The older tertiary rocks consisting mainly of eocene shale and numilités of narrow basin in West Nepal.

Similarly, the Central Himalayan thrust differentiates the higher Himalayan protozoic crystalline metamorphic rocks from underlying pre-tertiary low to medium grade metamorphics. The crystalline rocks of the Higher Himalayan Zone forms the basement for the Tethysian sediment which present feasilliferrous rocks ranging in age from Cambrian to tertiary in Thank Khola and Langu-Manang synclinorium.

From economic aspects, the tertiary basin forming the southern fringe of Nepal and higher Himalayan Tethysian basins indicate good prospect for oil and gas and also many areas show gas and oil seepages.

The pre-tertiary with intrusive granite and basic rocks reveal wide occurrences of metals like Cu, Pb, Zn, Fe, Co, Ni, Mo, W, Au, Ag, Uranium and other non-metallic minerals.

2. 2.2. Geo-morphology.

Geo-phisically the country is divided mainly in four regions:

(i) Northern Region of high snow clad mountain

(ii) Central Regions of densely populated area and

(iii) Siwalik Regions with low water retention capacity and

(iv) Southern Regions of Terai (an extension of Gangetic Plain) and Inner Terai.

The altitude of Northern Regions varies from about 5880 m to 8848 m. It constituties about 33 percent of the total area of the country (i.e. 46,720 Sq.Km.). The altitude of the Central Regions varies from about 1830m to 5880m. It covers about 36 percent of the total area (i.e. 50,968 Sq.km.). The Chain of mountains in this is called the Mahabharat Range and extends from East to West with altitude varying from 1520m to 3660m.

It has innumerable number of perennial streams. The big river valleys like Kathmandu and Pokhara are also located here. Kathmandu is the Capital of Nepal. The area, altitude and population of Kathmandu Valley is 648 Sq.km, 1400m and 500,000 respectively.

Siwalik Regions is a small strip also running East to West and comprises about 8 percent of the total area (i.e. 11326 Sq.km). The altitude varies from 610 to 1830 m.

The altitude of Terai and Inner Terai running East to West are below 300m. The width varies from about 16 km to 48 km and comprises about 23 percent of the total area (i.e. 32,562.92 km).

3. Hydro-Meteorological Conditions.

3.1. Precipitation.

Hydro Meteorologically there are two rainy seasons. The South - East monsoon brings more than 75 percent of the total annual rainfall and occurs between mid - June to mid - October. The Winter rains and other scattered rains account for less than 25 percent. The annual precipitation varies from about 250 mm. in the dry Western region and 3500mm in the West Regions. The annual average is 1516 mm.

3.2 Temperature.

In the Southern Terai and Inner Terai, the temperature goes as high as 44° C in Summer and - 4.4°C lowest in Winter. The temperature in the Himalayan Region is below 0°C.

3.3. Climate.

The West generally receives less rainfall than the East Mugu district receives the least amount of pricipitation, less than 500 mm. However, rain in Jumla is only one-sixth of that of Pokhara. The maximum rainfall occurs in Pokhara (3770 mm). The Inner Terai and Chure regions (Siwalik) receive about 2000 mm to 2500mm of procipitation. The rainfall record in Damak and Rainbirta in the Eastern part, East-of Koshi receive about 2000mm to 2500mm. The rainfall record in Dharan, Biratnagar, Dhankuta and Namche Bazar are 2000 mm, 130°mm, 806mm and 830mm.

4. Rivers and River Basins.

4.1. Rivers.

4.1.1. Classification.

The rivers in Nepal are hydrologically classified into three types as follows:

i) The rivers with their sources in the snow and glaciers in the Himalayan region.

ii) The rivers originating from Mahabharat Range below snow line and are fed by ground water including spring and have sustained dry season flow.

iii) The rivers originating from Siwalik Range. They have either very low or no discharge during dry season.

4.2. River Basins.

Nepal consists of three main river basins. They are Sapta Kosi, Gandak and Karnali basins. The other important river basins are Mahakali, West Rapti, Bagmati, Kankai Main river basins.
There are about 6000 rivers in Nepal. About 1000 rivers have lengths about 11 km each and about 100 rivers have lengths about 160 km. The total lengths of all streams and rivulets exceeds 45,000 km.

Thus the drainage density expressing closeness of spacing of channels is approximately 0.3 km per square kilometer.

5. Records.

The average minimum specific run-off of 38 rivers with catchment areas varying from 4 to 42,000 km^2 and which have been gauged regularly since the past 14 years in 3.7 $l/s/km^2$ with a standard deviation of 2.6 $l/s/km^2$.

The average maximum specific run-off of the same rivers amounts to 1.5 $m^3/s/km^2$ with a standard deviation of + 1.4 $m^3/s/km^2$.

The correlation between the specific run-off and the catchment of the Nepalese rivers show similar tendencies as has been found by statistical analysis of rivers from countries with longer hydrological records, i.e. the minimum specific run-off increases with the size of the catchment area whereas the maximum specific run-off decreases with increasing size of the catchment.

6. General Back Ground.

6.1. Demography.

Of the total population nearly 50 percent live in hills. Around 90-percent of them are agrarion. Shopping supplies are reached through small townships or shopping centres. The average distance for each household for shopping is about 5-7 km. Leaving out the small business community. rest of the entire population live mostly scattered. Most families own on an average about 0.2 to '8 hectres of land, 4-5 heads of cattle. pigs, horses, fowls.

The demographic pressure is increasing at the rate of about 2 percent. Besides, there are approximately 7-8 million animals in the hills. In lack of compatible economic activities, most people depond on agriculture production which is gradually, decreasing. Fuel requirement are met through fire wood from nearby forget. The cattles and other animals are second important source of economy. They supply milk, meat, leather and manures. Subsequently the requiments for grasing pasture land are increasing. Refer to attached map on population density.

6.2. Migration.

When the local resources get scarcer, some young men start to move out in search of work. Some migrate from one place to another within the country and some emigrate to neighbouring countries.

The Terai plains being fertile the family migration towards Terai is very high Random settlement of such families in the Terai plains caused devastation to many forest areas. The Govt. had to initiate continuous rehabilitation program.

.3 Forest.

The fast deforestation of the hills in Nepal give an impression of the extent of the prevailing energy deficit in the country and of the urgency of the supply of alternative energy resources.

In some localities fire is use to open up now land. Where the newly claimed soil is not fertile enough, dried sods, woods are collected, bushes are [illegible] to burn them for good ash. This would give a very good potate drop b[illegible] lifting. Cowherds hunters and children also light fires to jungles sometimes. Like this jungles are enchroashed. According to climate and local building styles, 50-70 cubic metres of wood is logged per house. Timber and firewood extraction, forest burnt down for cultivation, grazing, lopping for fodder and burning of the under-growth, in conjuction with timber utilisation for constrction are causing a general degradation of the forests by thinning, overaging and local destruction.

.4 Fodder & Livestock.

Fodder in the junble is disappearing very rapidly. The livestocks(cattles) are fed more and more and more on paddy and wheat straw. The prospect of having more animals are getting deemer.

.5 Farming.

While the good farmers who have enough cattle and do very intensive cultivation can still increase their yields, in most cases farmers are getting lesser yield even with the some effort put in about 10 - 15 years before. The rain washes away the most fertile top sail every year.

Demand increase because of population growth whereas availbility decreases. People have less and less fuel and fodder, they cannot claim any more land.

.6 Fuel.

About 85% of the total energy consuumption is contributed by fire-wood. The per capita consumption of fire-wood is 600 kg/year while the regeneration is only 80 kg/year. As a result 1,20,000 acres of forest are depleted every year. The Govt. is earnest in accelerating re-plentation program, reach alternative energy expetitiously and effective management on forest uses.

6.7. Traditional Industries in the Hills.

The typical cottage industries are weaving with cotton or wool, iron or good, smith leather tanning and shoes making, tailoring,earthen pottery, wood metal craft in branze, brass or copper, producing lac, carpentry, making bamboo products, rope or string, running water wheel slate mining, lima making, tiles or bricks or terra-cotta,handicrafts, Nepali paper, bee keeping etc.

These activities are carried out seasonally or in liesure time free from agriculture works. Further these activities are traditionally limited to certain ethnic groups of people, generally coming from poor social backgrounds or poor bill communities. They comprise about 15 percent of the population.

6.8. Medicinal Plants.

Nepal has always been a previleged country as far as collection and expert of medicinal plants is concerned. These are used in the Hindu culture as well as in those of Tebetans and Chinese. The local heaters of the different ethnic groups make quite a lot of use of these plants. They are widely used in the preparation of all traditional pharmacocia.

There are more several hundred medicinal plants known in Nepal. All of them can be developed and exported. At present these comprise about 3% of the total experts.

The Govt. is promiting its development at all levels.

6.9. Horticulture Potentials.

Nepal hills have great potential for fruit growing. However,the problem of intensive fruit production in the hills is the remoteness of the areas which are favourable for horficullars Long-access routes make it impossible to transport fresh fruit economically to market areas. Some sort of processing would be needed. It is hoped rural electrification can play an important role in supplying energy for fruit processing. Thus opening opening a new possibility of cash generation in remote areas.

Alongwith this Processing activities like fruit processing - making jam, jelly, cocentrates, juice, dehydration products, milk processing-making ghee, cheese, most processing - salted dry meat,canned meat, wool processing of carpet making and allied products,hide processing - making shoes, bags, coats, Fodder industries can be built up from the bye - products of fruit processing and milk processing. Sub-

Subsidiary industries for packing material from forest products like planks and bamboo can be started. Immense possibilities to enhance hill economy, therefore, exists.

6.10. Tourism.

Tourism is a recent phenomena in this country. Handicrafts wild like, postage stamps, coins and a host of other tourist subside as well as the famous Himalayas and favourables climate, it is believed, house attracted tourists. Besides some natural scientists, nature lovers and host of other foreigners also come. Thus far, this industry has played on effective role towards the development of the national economy. However, tourism has its dark side also. In order to keep the tourist industry thriving for economic return and international brother wood, proper balance between the tourism promotion and fracilo mountain ecology from deterioration would be needed.

6.2. POLICY & PROGRAM.

6.2.1. Water Resources.

No significant success is achieved for economic exploration of oil resources. Coa - mines are not yet located within the country. Use of solar energy is made for drying crops, Fodders, cereals etc. in the traditional way. Assessment of necessary technology for development of wind power is not yet begun Forests resources are depleting fast.

If Nepal is endowed with any natural resource, it is water, out of the total annual run-off of 17 billion cubic metres 148 x 10^9 cubmic meters are formed within the country. The will be equivalent tea water depth of 1.1 meters over the whole are of the country. Added to this, the favourable topographical features lends Nepal to immence hydro-power potential of about 90 million kilowatts. This gives a cadestral distribution of approximately 600 kw per square kilometer.

Until now only 0.07 percent of the above potential is developed and only about 4.5 percent of population are being served.

6.2.2. Development Strategy.

Besides complenting other uses, Nepal's Water resources is is planned to be developed in thre main categori s. Large scale project like Karnali (3600 MW) are primarily aimed dor expert to neighbouring countries. Medium sized projects upto 100 MW size are meant for internal consumption in reletively developed region like the Central Regions and Terai. The third catagories of projects are the micro-hydel projects primarily are considered to be useful to the Hills.

6.2.3. Rural Electrification.

Govt. Policy being implemented through the Fifth Development Plan (2031/3. 2036/37) envisages to more evenly distribute the benifits of economic and social development to the poorest remote regions of the country. The integrated program places a high priority in bringing rural electrification to the hills region where lives the greatest part of the agrarian population. There areas have no supply of electricity and due to their isolated mountainous locations, for many years will have no prospect of being supplied from future large hydro-electric projects.

6.2.4. Choice.

Having considered the alternative of small diesel generating plants, the Govt. has determined that only practical approach to electrifying these isolated rural regions is by utilising the locally abundent water flow for micro-hydel schemes. Because such schemes require a relatively small amount of capital, indigeneous resources, and a short implentation time schedule. They can effectively respond to the immediary of the development problems in the outlying communities. Furthermore, they are small projects simple is design which can be implemented by mobilising a maximum of level talent, labour and materials providing, thus, a more direct participation of the people in the development of their own area.

In view of the imense possibilities of development of the small scale agro-based industries in the Hills, the supply of electric energy is part of the necessary infra-structure for stimulating economic activity and growth. His Majesty's Govt.'s on-going rural electrification program is part of its integrated development approach and a deciding contributing factor in attaining three of HMG's major development objective - (a) Create oppurtunity for rural economic growth, (b) reduce out-migration of the Hills population and (c) dominish depletion of forests.

6.2.5. Project Appraisal and Selection.

As resources in Nepal both in skilled manpower and in material are scarce, special attention has to be given to the selection of projects inorder to make sure, that the limited resources are employed in a most profitable way.

Small hydel projects can and should be appraised on different levels and bases. Thus a small hydel project can be appraised roughly from the following viewpoints.

- national and regional development planning and evelopment aims.
- masterplan for the step by step electrification of the country.
- or the project level.

Additionally according to sofar prevailing practices in Nepal, small hydel projects are being appraised depending on the emotional attachment of some decisionmakers to a particular project.

2. The different viewpoints.

It is clear that the above mentioned viewpoints are strongly intedependent and project appraisal has to consider all the aspects. Independently from the viwpoint from which the projects are appraised, there always exist basically two different approaches which shall be outlined below:

2.1. National and regional development planning and development aims.

One possible and actually traditional approach would be, to select projects which promise the best return of the costs in the shorted period of time. This would among other require the project to be:

- within easy reach of a transportation facility (road, STOL airstrip)
- in an area with a good potential for economic growth and where already some economic activities exist.
- somewhere where a minimum infrastructure already exists.
- in an area where the population density promises a good respons to the new project. /1

This approach toward a straight forward income maximisation, which in turn could lead to a concentration of investment in favour of the places and groups with the highest productive potential to the determent of the others. 1 With this approach, basing the selection of small hydel projects purely on the rate of pay off in terms of net socio-economic benefits, less promising areas tend to become entirely neglected. Keeping in mind the number of such less promising areas, such an approach thus would be socially unjust and even politically unwise.

Hence full scale socio economic benefit cost analysis procedures which would lead to such an approach are not justifiable for small hydel projects. (See also 2.3.). A sensitivity analysis, giving infor-

information about the tolerance of rising cost benefit ratios within which a project still could be justified, seems much more appropriate in this context. /2

The other approach on this level of project appraisal is to select projects or projects areas with the aim to spread investment as widely as possible with only a secondary concern about the economic pay off of the project. This would mean that the main criteria for selection of a small hydel project would be the grade to which the most defavourised people in the country are reached by the project as well as to number of people profitting from the project. Stating that the social consequences of neglect in remote rural areas far outweigh the risks of limited economic success, the typically best area for a small hydel project would thus be a densely populated, remote area, far from any transport or other facilities with sofar not much development activity. Still a sensitivity analysis would have to show how far one could go with this approach.

/1 VIKAS , "A/journal for development" (National Planning Commission) Vol. 2. No. 2. p 17/ ff

/2 CEDA, Regional Development Study, PART I, Chapter IV E

HMG sofar has tried to rather follow as far as justificable the approach of spreading investment as widely as possible.

2.2. Masterplan for the step by step electrification of the country.

Sofar no detailed masterplan for the electrification of Nepal exists. Different agencies and projects however work jointly toward the aim of establishing such a plan. Even without masterplan, the alignment of some major HT-transmission lines is already fixed and some tohers are in a planning stage. It seems logical that the backbone of a future grid will follow the most densely populated areas of the country(see attached map) and first supply these areas. Not just by chance, the major ongoing and future road projects actually follow roughly these population concertration areas as well.

Even though no electrification masterplan is readily available, two distinctly different approaches to select small hydel projects from the viewpoint of a national electrification masterplan can be imagined.

One possible approach would rather follow a policy of spreading investment as widely as possible as mentioned under 2.1. Projects thus selected would rather lay outside the densely populated areas of the country, which sooner or later are likely to be served by a HT-line.

This approach at least in a short term to medium term planning tends to make best possible use of the scarce resources to realise rural electrification by not investing in relatively costly small scale electrification in an area which could be electrified later with little incremental costs, regarding the costs for the HT-transmission line as sunk costs.

The other approach would be to regard the small hydel schemes as a means to build up a power market in a rural area and thus "prepare" for a further investment in a connection from a future grid line. An already existing powermarket could in future more easily justify a costly sub-station. The costs for building a small hydel plant and for the alternative extension of or connection to an existing or planned gridline should however be compared carefully. The small hydel station become obsolete through the construction of a HT-transmission line, could then be reinstalled in another project in a remote area, provided that a matching site can be found.

The decision whether to adopt one approach rather than the other largely depends upon the time factor: if a HT-transmission line already exists or is going to be constructed within the next ten years from the moment of decision, in most cases one would rather relay on the electrification through connection from the grid then building a new powerplant, provided, that the cost comparision favourises the connection.

In the case of a HT-line to be built in farer future (within the net 50 years), a small hydel plant could bridge the time gap untill electricity would be available from the grid and at the same time build up a market for electricity, so that a future connection would have a good economic return in a short period of time.

To adopt one or the other approach depends on the distance of the HT-transmission and with it on the transmission voltage as well. It is evident that building a substation for a 500 kV line for a load centre with an expected peak load of 100 kW only or for an area where sofar no market for electricity exists would be moere difficult to justify economically than a substation from a 132 or 44 KV line.

2.3. Choice on the project level.

Sofar about 40 different possible sites for small hydel plants have been identified in Nepal and about 150 are actually under investigation the following tries to outline some possible procedures to select among projects which would have the same ranking from viewpoints 2.1. and 2.2.

Here again two different approaches exist and can even be discerned in the actual project identification practice in Nepal. One approach would tend to satisfy by any means the domestic demand in a load centre. As cooking by electricity directly produced from small hydel plants sofar can be ruled out, this domestic demand is limited to lighting mainly. Oftern, due to selection of inappropriate sites or non availability of better sites within a reasonable distance, the capacity of the small hydel plant is limited. This approach now tends to supply electricity to the domestic consumers in first priority. The demand from domestic consumers however, due to excessive use of electric bulbs as an expression of social standard very often exceeds the foreseeable demand which would just satisfy the basic needs of lighting. This approach roughly would tend to size a project mainly on the base of domestic load forecast, supplying only surplus energy to productive users.

The other approach in this context would rather try to first satisfy all the demands from productive user categories and supply only surplus energy for domestic lighting demand. The sizing of the project thus would rather consider productive uses in first priority.

It is clear, that the choice seldom is done fully in favour of one or the other appreach. The following points should however be kept in mind when comparing equally ranking projects:

Though as stated before, full scale benefit cost analysis procedure is not justified for selecting small hydel plants, on this level of comparision a rough estimate of the internal economic rate of return(IER) might be helpful. A low IER apart from showing that the investment in question is inofficient, might indicate a low demand for productive uses. Thus among two projects the one with the higher IER is naturally given priority. Or put in another way two projects could simpply be compared on the bases of the level of demands for productive uses. Where there is a strong demand for productive uses a rough benefit-cost estimation will be sufficient to justify a project, where on the other hand, the demand for productive uses is now, justification will be difficult. /3

Other points on this level of comparision definitely play a role of similar significance. As for example the purely technical features and feasibility. A project with a sjort canal compared to the head should for example be given priority over 2 projects with a low head to canal length ratio. As resources in Nepal are scarce, the project which involves as much as possible local know how and local material makes certainly best use of the available resources and hence should be given priority as well over 2 projects using lots of imported goods such as cement and steel.

3. Choice of projects to which decision makers are emotionally attached.

Due to the lack of a masterplan for rural electrification it may happen, that small hydel projects are selected for prioritary implementation on the base of a simple demand from a person who is somehow emotionally attached to the project which he asks for. It may as well happen, htat one somehow instinctively feels, that this particular project might or might not deserve the priority which is actually attached to it. The time has come however for Nepal as well not to base decisions for project implementation on "instinct" but on scientific tools as outlined in this paper. The elaboration of a masterplan for rural electrification could further help to refine these tools. The aim is to reach a certain standard of project evaluation which would allow to classify all small hydel projects according to a certain key, based on criterias as outlined and accepted by all decisionmakers. It might then well be that certain projects which are proposed on the base of an emotional attachment are identical with the projects as selected according to such a standarised procedure. Where there would be some discrepances however, one could with the help of such a tool classify that particular project in the order of its priority and could give firm advice on the bases of a widely accepted procedure.

/3 "Rural Electrification", a World Bank Paper, October 1975

2.5. Programs.

Under the policy guidance outlined, HMG has liberally expanded its program for rural electrification. Out of total 75 districts, all Terai districts have been electrified through extension of Indian grids or by installing diesel plants. Urban area like Kathmandu, Pokhara and the areas where existing Hydel projects are located have received electric supply. Remaining about 45 districts in the hills have no electricity so far.

The first micro-hydel station at Dhankuta was (2x120 kW) completed by 2025 B.S. in Eastern Development Region. The second one is the Surkhet (3x115 kW) in the far Western Development Region. The consumption pattern of electricity energy in these areas have provided certian basis for further program.

Real efforts were put in only since B.S. 2033, whereby number of projects were taken up for construction. Two projects viz Doti and Namche were started by F/Y 2033/34. Additional 5 projecgs viz Jumla, Jomsom, Phidim, Baglung and Salleri were started by F/Y 2034/35. By B.S. 2035/36 other 5 projects Taplejung, Khandbari, Bhojpur, Okhaldhunga and Ramechhap were put under program. Ref Table No.... for salient features of these projects.

Besides the construction program, continuous investigation programs were initiated by F/Y 2033-34, Pro-feasibility study for a project in 18 different districts were completed. Subsequently other districts were studied and suitable load centres and generation sites were selected. The list of projects with salient features are shown in Table No......... (B.S. stands for Bikram Sambat, the national calendar. The year of the national calender starts on 14th of April of the accidantal calender. the year B.S. 2036 stands for 1979/80).

7. Some specific Problems.

7.1. Survey and Design.

Everybody, working on development in Nepal certainly already felt drastically the lack of good upto data maps in adequate scales of a any particular area of the kindom. The existing maps in a nonmatrid scale are in most cases just correct in the rough topographical features of the area but out-dated and even incorrect in some cases with regard to mapped details. This first of all makes it impossible to make useful preliminary selection of good sites for generating power from map study only. Very often, sites selected on the base of the existing maps, prove not feasible on the spot and through power and time consuming procedure on other sites has to be looked for in the field, sometimes even in another river.

If this lack is felt for small scale maps, it is even present in case of large scale mapping. Large scale maps of Panchayats or smaller areas like wards or so are virtually non-existent in Nepal. This makes it necessaru to have a survey town to be sent to the selected sites to make an accurate detailed mapping of the area.

There another problems arises: It is difficult if not almost impossible to get skilled, well trained surveyers with sufficient experience to make a large scale map of a construction site, which could meet the requirements of the detail design. Skilled and experienced surveyers are mostly engaged in the important task to compile the so much needed survey datas from within the survey department. Thus the maps arriving in the Central Office though looking nice very often, are of not much use for the detail design. It happened in one particular project under construction, that for example the penstock alignment be designed in the Central Office had to be changed thrice, due to inaccuracies of the submitted maps.

This again calls the problems of the lack of good communication and transport facilities between the Central Office and the some times very remote construction sites. An inaccuracy in the site map or lack of details shown. On it, may necessitate one or several journeys between the Central Office, where the design is done and the construction site which is a very time and consuming and in the end unproductive notivity. The problem of lack of connunication facilities between the construction sites and the SHDB Central Office, however, are going to be seasoned by the installation of wireless set connections between the head office and the sites.

At the fact, that planes to remote places in Nepal are usually booked out months in advance and seats are often not available on short notice as it is required for the above mentioned movements between Kathmandu and the sites, will probably not improve in the near future, one has somehow to cope with.

One possibility to overcome all the above mentioned problems would be to decentralize the design works, i.e. make the design for each project directly on the site in the field. For this kind of work the standard of the so far submitted maping could even meet the requirements, as additional measurements can be taken at ease whenever and wherever needed.

This approach, however, generated another problem: the problem of lack of skilled manpower. At present 4 civil engineers in the central office manage the civil design work for 6 or 7 on-going projects.

The proposed alternative apprach with the design work being done at the site would there-fore require one civil engineer on each of the seven on-going sites. This could be schieved by replacing the present electrical or mechanical engineer site-in-charge by civil engineer site-in-charge, or by giving more decisive power and instruction to the civil staff, already on place. There however arises the reqruitment problem for civil engineer staff who is rady to stay two years in an average in the same place as the site-in-charge.

At present the mentioned short-coming is tried to be overcome by assigning the detail design work to local consultant firms. The experts rates for fieldwork however are not available to send them one month or more to the site for detail design, not the authors of the detail design ——— is available from time to time for site visits during the construction period.

7.2. Construction.

Nepal is a country which has almost infinite resourcese and local know-how of water engineer. Trekking through the country side, it is amazing to see how skillfully local people build diversion dams even in big rivers and canals, moandering along the slopes, crossing rivulete with log-superpassages and clustered to steep rock wells in the most artiscal way. Thus diverted water is used either for irrigation or to drive local water-mills (Ghattas).

As a matter of fact this existing local technology is not enough made use of by consultants for engineers as far. Upto now the design for canals is mostly done in a way to get straight alignment sections connected with exactly radial curves. It is true that such a design works pleasant on a map, in the field however, the straight alignments cause very often deep cuttings on the hill slopes, thus while constructed, destroying big surfaces or valuable vegetation cover thus creating big erosion hazards during monsoon rains. The alternative and more appropriate approach as practised by local people, destroys the ecologic balance as little as possible by following the contour lines to the maximum possible extent.

The design for diversion structures and headworks as practiced actually,usually uses a lot of cement. The availability of cement and blasting materials is very often the crucial point for the implementation of project. Sometimes no cement is available at all or then the project is in such a remote place, that the transport of the cement along would require more time and cost then was scheduled for the construction period of the project. Moreover hydrological and geological datas are very scarce and there is very little experience in constructing hydralic structures in the Himalayan-Foothills. Thus even a heavy reinforced cement concrete structure is subject to being destroyed by a hydrological or geological event which was not prodictable on the basis of the available datas.

In such cases, where the force of the nature annot be assessed exactly and therefore adequate measures to encounter those forces cannot be found, the most appropriate tecnic is not to offer any resistance to these force. This is actually the approach used by local people: building simple structures with local material only, accepting that they will be washed away annually by heavy monsoon rains. The same approach could be used for construction of small hydro power stations. As labour costs for repair and rebuilding the damaged structure is comparatively low in contrast to imported goods like steel and cement, this approach would prove more economical even on the long run then the so called scientific methods with lots of cement.

One has however to be aware that this local or appropriate bears with it some problems as well. The best felt problem with this approach certainly is, that all the technical decisions which were at the base for the design of a structue are not reperformable so there are no formules for it. Thus this approach needs much more experience and a good deal of common sense as well as a better fooling for the force and the flow behaviour of the water, then the "scientific approach" using formulas for the design of every single structure would require.

This lack of reperformability is the crucial point which makes it difficult to comply normally with and regulations: according to the rules and regulations, a detailed cost estimate has to be submitted for each project along with detailed plans and cross-sections for all structures. As with the above described appropriate approach all the structures slowly developed under the eyes of the supervising engineer by some kind of trial and error method, taking into account all local topographical, geological and hydrological features, it might prove difficult if not impossible to produce an accurate design for

for each structure beforehand. However, with the inaccuracies of the survey datas actually at head, even a rough design and cost estimate is probably more accurate when it is done on the site directly using an appropriate approach, then the present cost estimates which are based on mostly unsatisfying survey datas and done from the desk in the Kathmandu Central Office.

The suggested appropriate construction method by trial and error however, collides also with the contractor system commonly is use for construction of such plants. As with this method no accurate and final plan can be handed over to the consultant. It requires a big deal more supervision from the contracting agency, than the common "Sehintific approach" where the contractor just has to stick to the plans with no regard to prevailing geological, topographical hydrological of soil conditions.

This however apain generates the problem of the availabilit of sufficient skilled and experienced personnel.

8.

8. Project Economics.

8.1. Rates & Unit Prices.

Legal rates for labour material and transportation were collected for different sites. The sources of data were:

i) Official rates gives by Chief district Officer.

ii) Current Rates used for construction works in the locality.

iii) Random collections on verbal information.

iv) Rates applicable to similar other projects.

Where different sources would apply priority is given in the above mentioned order. From there, as well as other relevant data, average labour rates and unit prices for various works have been computed. The rates and unit prices vary from site to site. The unit rates include labour, material, tools, statutory taxes and contractor's profit. They are depicted in table 4.

All major cost items are specified in the cost estimates. Smaller items are included in miscellaneous works. The percentage for miscellaneous items are usually vary between 5 to 10 percent.

Engineering, supervision, administration and contingencies are included with percentages varying between 5 and 10 percent.

All rates prices used in the cost estimates are reviewed in the begining of each fiscal year.

8.2. Construction Cost.

8.2.1. Preliminary works.

The Preliminary works will mainly consist of additional survey of the project site, review of the power market study for planning distribution net works and final engineering designs. Also improvement or access to sites, building temporary and permanent bridge etc. These costs items are partly included in the Engineering costs and partly in the Miscellaneous works.

The permanent buildings for the operation of the power plants, storage and accomodation for project staff.

8.2.2. Transportation.

For imported material from overseas the transport cost upto Nepal/ Indian Border is estimated at Rs. 4000 per ton. The cost due to provision of transit stores at the border is added to the transport cost. From the border, the materials are transported directly by Helicopter/ Twin Otter, Skyvan in some cases, at others they are transported as far as possible by trucks and thereafter by air transport or porter. The cost of the helicopter per hour is 5000/- for small and Rs.11,000/- for Puma and varies from Rs. 4000/- to 6000/- per ton by plane/Costs are shown in Table 5.

8.2.3. Civil Works.

The cost of civil engineering works is calculated on the basin of the local rates and unit prices. The house building costs are based on a price per m^2. Cost of use of land is Rs. 500-2000/- per ropani, (i.e. 1/5 of an acre).

8.2.4. Electro-mechanical Equipments.

The cost of these equipments are based on FOB prices for equipments of overseas manufactures derived from preliminary quotations and partly on earlier tenders .

8.2.5. Transmission Lines.

The prices for conductors, insulators transformers and hardwares are imported and the prices are partly checked by earlier tenders and partly on quotation. The costs of poles are derived locally. The ave-

average cost per km of 11 KV lines and distribution networks are estimated as Rs. 80,000/- /km and Rs. 70,000/- /km.

8.2.6 Local and Foreign Componets.

Foreign cost components are calculated on the following basis:

For civil works only cement and reinforcement steel are assumed to be imported. Foreign cost componant for cement will be Rs. 1200/- per Ton and Steel is Rs. 4,000/- per ton plus 70% for transport. All costs due to electro-mechanical equipments including transport to site is the foreign cost component. All imported line materials are foreign cost component.

8.2.7 Operation Costs:

The following staffing pattern is adopted:

Supply:	1. Senior electrical/Mech. Overseas		- 1
	2. Account/Administration clerk		- 1
	3. Line-men	-	- 2
	4. Watchman	-	- 2
	5. Seasonal labours	-	- 3
Power - Station:	Operators	- -	- 2
	Watchman	- -	- 2
	Seasonal labours	-	- 3

8.2.8 Economic Considerations.

General Approach.

Micro-hydel schemes are viewed in the context of benefit accruing for HMG in saving of foreign exchange for imported diesel, kerosene oils and dry colls for transistor radio as well as increased independance from foreign supplies.

Some broad assumptions for evaluating the expected economic rate of return are:

1. The average maximum selling price of energy to consumers Rs. 0.75/KWH.
2. Monthly domestic consumption/consumer varies from 15 to 24 KWH/month within 15 years period.
3. Gestation period for the plant 15 years.
4. The average domestic consumption per month during the 15-year period

is assume' at 22 KWH/month.

About 75% of this usage is atributed to lighting needs and 25% to heating and cooking needs.

3. Over the 15 year period 50% of total energy sales were estimated for all consumption other then domestic with 40% of such usage being attributed to lighting needs and 60% to motive power and heating needs.

4. The implemention period for the project is 2.5 to 3 years

5. The opportunity cost of the capital is 12%.

6. The average cost of one litre of kerosene in the project area is Rs. 6/- and it takes about 2 litees of kerosene to produce/KWh of light.

8.2.9. Cost Break-down.

Cost break down for each scheme for a major category of works (civil, electro-mechanical, transmission) is given in Table .... The total cost of these three categories of works in increased by 20% to provide for engineering and supervision (13%) and contingencies(7%).

9. Possible Alternative Energy Resource.

While speaking of alternative energy resources in Nepal, we understand energy alternatives to:

a) Fuel like would, straw, cowdung, sawdust, hay etc.

b) Oil products like kerosene, petrol, diesel oil etc.

For the line being, practical experience with alternative energy products is very limited. Our practical understanding of the term "alternative - energy resources" can be define as follows:

"The natural energy resources viz water, sun, wind and gas should be transformed by a simple technical device into a from which would be allow the inhabitants of this country to use these energies. And such energy sourеces should prove economical in the long run than the traditional energy sources without further deteriotating the ecological balance."

HMG. has been working on this line for quite some time. In view of the ever increasing international oil crisis and acute national fuel crisis added to the growing ecological damages. HMG. has earnestly initiated the development of the alternative energy resources in the following line of priority to begin with.

(a) Mini-hydel plants.

(b) Gobar Gas plants.

(c) Solar energy and

(d) Wind power.

In order to transform such natural energy certain technical devices, however, are required.

9.1. Mini-Hydel Plants.

Vertical axis water wheels have been in use for many decades in Nepal. They are used mainly to drive simple traditional flour mills. Their low efficiency and limited size make them adequate for this purpose only.

Balaju Yantra Shala Pvt. Ltd., Butwal Technical Institute and few other workshops have already are on manufacture of suitable devices.

With a power output of maximum ten house-power,manufacured by Balaju Yantra Shala and Butwal Engineering works, these turbines are driving various mills in many district and have provided a reliable substitute for diesel plants.

A turbine-pump manufactured by BYS (30 H.P.) is planned to be installed at Bholatar pump Irrigation scheme in Lamjung district.

A 5 KW size Balaju made turbine is installed at one locality in the district of Mustang.

9.2. Gobar Gas.

When the fire-wood are in short supply, the famous are using cow-dung other dunge as fuel in the form of dried cakes with drawing from their fields the much needed fertilisess.

Thus developing a plant to gain methane gas from animals dung would be economically viable in most cases, where kerosene, wood and other fuels are becoming limited. Further these plants will be useful in view of the distribution of the housing pattern in the hills. Plants for individual family could be built at less cost where transmission lines for isolated housing become costly. With cost effective measures for gas chambers, the cost of each plant works out to be around Rs. 4,000/- per plant of $1m^3$ size. Further most of the works could be accomplished locally. More than 200 plants have been built so far. The best working temperature for these plants would be 28-32^{o}C.

9.3. Solar Energy.

Since long Nepalese are using solar energy for drying crops, carseals, hays, clothes. Recently the solar water heaters are becoming more prevalent. The more common types of modern technical devices and its competitiveness of development is not yet established.

9.4. Wind Energy.

Uses of wind energy may be best suited for driving a pumping set, pumping water for irrigation or drinking purpose.

10. Generating and Construction Equipments and Tools.

10.1. Generation Equipments.

10.1.1. Hydro-mechanical.

Cross-flow turbines upto 60 kW size operating under a head upto 60m could now be manufactured locally by Balaju Yantra Shala and Butwal Engineering Works. The Penstock until now are from steel and are fabricated locally also by the above Engineering workshops. The cost per KW is about 1800 - 2200/- and cost per ton of penstock 20,000/-.

10.1.2. Generating Equipments.

Alternatives, switch board panels, power cables and all accessories until now is imported. The cost per kW is about Rs. 3000 - 6000/-.

10.1.3. Transmission & distribution line Materials.

Excepting the wooden poles all the materials are imported. The cost per km. varies from Rs. 50,000/- - 80,000/-.

11. Construction Equipments, Tools & Instruments.

11.1.1. Construction Equipments.

Only construct on equipments required are:

1. Portable Drilling machine with attachment of .... 2 Nos.
2. Concrete Mixer - - 1 No.
3. Vibration needle - - 2 Nos.
4. Pump 3-5 H.P. - - 2 Nos.
5. Radio-set - - 1 No.

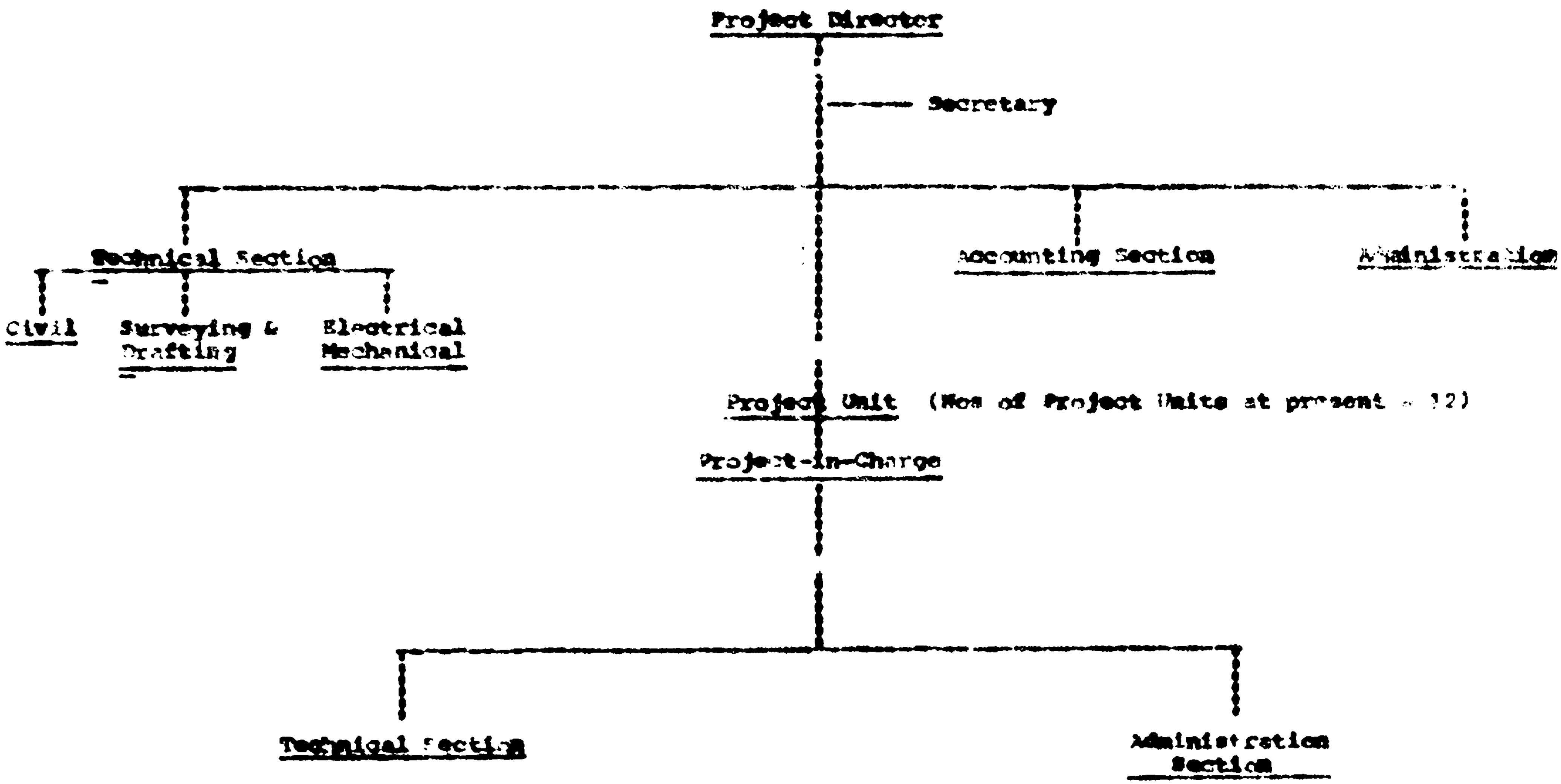
11.2.2. Construction Tools.

1.	Pick	-	10 dozens
2.	Hard Shavel	-	10 dozens
3.	Spade	-	10 dozens
4.	Crowbar	-	10 dozens
5.	Ropes	-	1000 meters.
6.	Winches	-	2 nos.
7.	Erection Tools	-	1 set.

11.2.3. Survey Measurements.

1.	Theodelite	-	1 no.
2.	Levelling	-	1 no.
3.	Levelling Staffes	-	4 nos.
4.	Measuring Tapes	-	4 nos.

PROJECT ORGANISATION OF SMDB



Dhankuta Micro-Hydel Project (Operation Statistics).

Installed Capacity = 240 kw.

1. Fiscal Year	2029/2030	2030/2031	2031/2032	2032/2033	2033/2034
2. Maximum demand	78	98	110	120	147
3. Energy Generation (KWH)	78640	132624	154805	180167	309449
4. Increase in energy	61309	90099	122755	152957	275327
generation (%)	-	46.95	37.45	16.38	
5. Energy sales (KWH)					
6. Load factor (%)	12	13%	16%	13%	24.0
7. System loss	20%	20%	20%	15%	11%
8. No. of Consumer (total)	245	307	412	511	564
a) Domestic	244	306	411	510	559
b) Industrial	1	1	1	1	4
c) Other	-	-	-	-	-
9. Energy sale classification (total) in KWH	61309	90099	122755	152957	275327
a) Domestic	45771	74994	101349	140370	231011
b) Industrial	15538	15105	13507	12587	30556
c) Others	-	-	7899	-	-
10. Energy Consumption per capita (KWH)	250	293	298	299	488
11. Operation and maintenance Cost (N. Rs.)	78500.00	77500.00	86103.00	92663.00	335000.00
12. Revenue (N. Rs.)	21416.00	31112.0	-	-	87297.-
13. No. of employees : 35					
14. Population : 4258					
15. Ratio of Consumers to population (%): 5.6					
16. Energy Generation per Capita (KWH)	313.0	367.0	376.0	358.0	540.0

Investment break down for Projects under construction.

Name of Project.	Installed Capacity	Total Expenditure (in Rs.)	Investment on Civil (works)	Investment on Hydro-Mechanical equipment	Investment on Transiv. & distribution system	Remarks.
Namche						
Doti						
Jomsom Hydel Project	240 kw	75,00,000.00	54%	31%	15%	percentage of told expenditure
Balleri	100 Kw.	29,00,000.00	42%	28%	30%	"
Phidim	240 kw.	46,00,000.00	48%	32%	10%	"
Baglung	175 kw	35,00,000.00	57%	27%	16%	"
Jumla	200 kw	65,00,000.00	78%	16%	8%	"

Estimates of Gross Domestic Project of Nepal

At current market prices

(Rs millions)

S.No	Sector	1964/65	65/66	66/67	67/68	68/69	69/70	70/71	71/72	72/73	73/74	74/75	75/76
1	Agriculture	3654	4794	4292	4883	5357	5922	6034	7106	6578	8851	9949	9709
2	Mining & Quarrying	1	2	1	1	5	4	1	2	3	3	3	3
3	Manufacturing	83	98	104	137	212	195	215	285	312	397	463	537
4	Construction	123	111	118	134	184	192	135	149	153	163	172	194
5	Transport & Coms.	91	93	102	120	141	192	234	285	347	422	453	693
6.	Cottage Industry	365	479	429	488	536	592	603	711	659	885	995	971
7.	Financial Institutions	69	80	82	86	106	128	139	145	163	193	306	285
8	Ownership Dwellings	654	663	683	698	714	729	745	782	779	796	813	831
9	Pub. Adm. & Defence	82	101	143	147	136	177	215	230	228	250	332	351
10	Electricity	4	5	8	10	16	18	20	23	29	28	34	39
11	Wholesale & retail trade	306	300	245	249	353	363	318	339	336	374	738	818
12	Services	170	178	204	219	235	256	279	332	382	456	544	749
		5602	6909	6411	7173	7985	8768	8938	10369	9969	12908	13802	15180

* Provisional

Source: National Planning Commission Secretariat.

Estimatates of Gross Domestic Product of Nepal

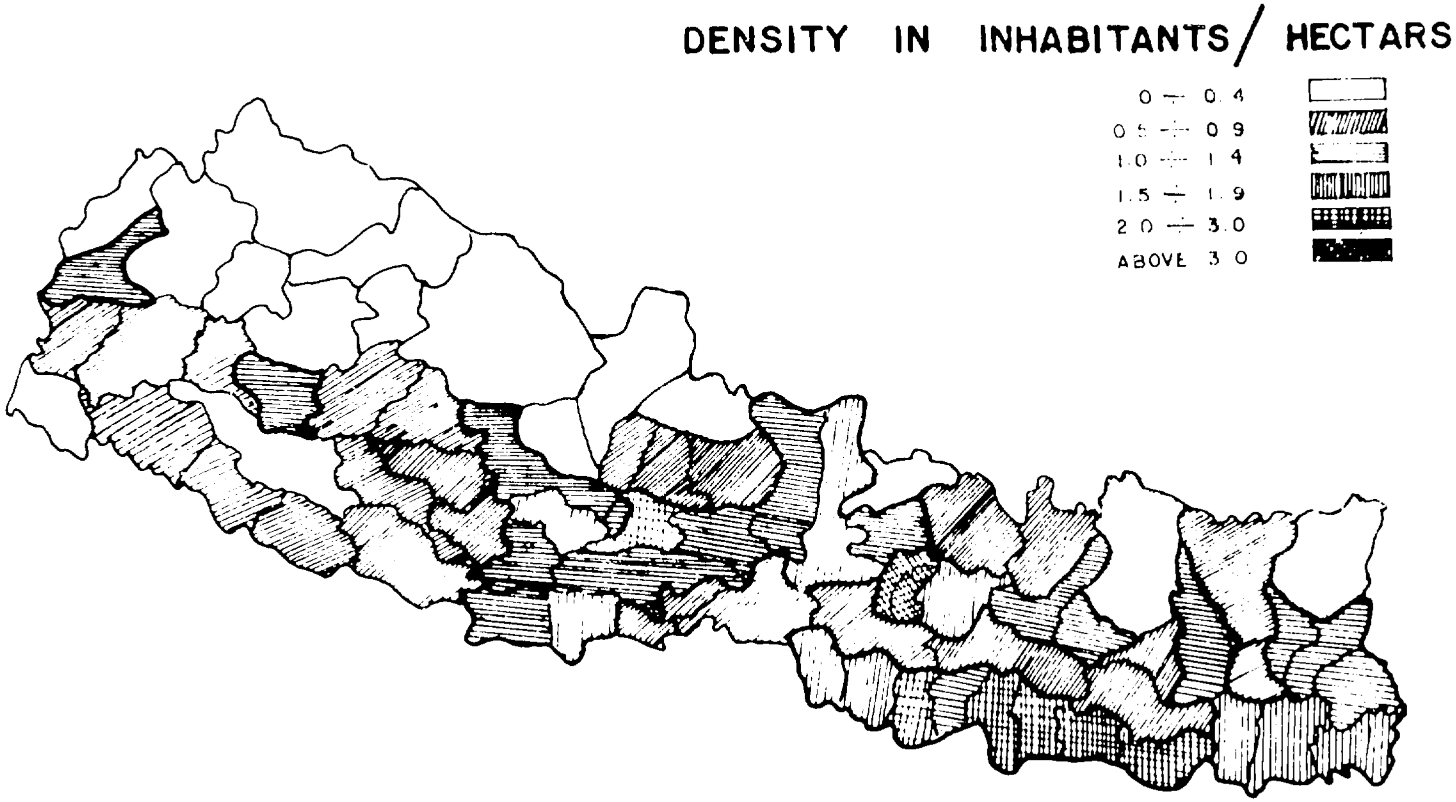
(At current and constant prices)

(In millions of Rupees)

year	At Current market prices			At Constant (1964-65) prices		
	Agriculture	Non-agriculture	Total	Agriculture	Non-agriculture	Total
1964-65(2021-22)	3654	1948	5602	3654	1948	5602
65-66(2022-23)	4794	2115	6909	4082	1914	5996
66-67(2023-24)	4292	2119	6411	3914	1988	5902
67-68(2024-25)	4833	2290	7123	3935	2007	5942
68-69(2025-26)	5357	2628	7985	4053	2154	6207
69-70(2026-27)	5922	2846	8768	4191	2176	6367
70-71(2027-28)	6034	2904	8938	4223	2068	6291
72-73(2029-30)	6578	3391	9969	4218	2238	6456
73-74(2030-31)	8851	3957	12808	4455	2410	6865
74-75(2031-32)	9949	4853	14802	4530	2435	6965
75-76(2032-33)	9709	5471	15180	4705	2262	6967

* Provisional.

DISTRICT WISE POPULATION DENSITY MAP OF NEPAL




NEPAL
SMALL HYDEL DEVELOPMENT
N
MAHAKALI
SETI
KARNALI
BHERI
RAPATI
DHAULAGIRI
GANDAKI
LUMBINI
NARAYANI
BAGMATI
JANAKPUR
SAGARMATHA
KOSI
MECHI
Darchula
Humla
Bajhang
Baitadi
Bajura
Mugu
Jumla
Dandeldhura
Doti
Achham
Kalikot
Dolpa
Kanchanpur
Kailali
Dailekh
Jajarkot
Mustang
Rukum
Myagdi
Manang
Bardia
Surkhet
Sallyan
Rolpa
Baglung
Parbat
Kaski
Lamjung
Gorkha
Banke
Pyuthan
Gulmi
Syangja
Tanahun
Rasuwa
Dangdeokhori
Arghakhanchi
Palpa
Dhading
Nuwakot
Sindhupalanchok
Dolakha
Solu khumbu
Sankhuwasabha
Kapilvastu
Rupandehi
Nawalparasi
Chitwan
Kabhre Palanchok
Ramechhap
Okhaldhunga
Taple jung
Makwanpur
Sindhuli
Khotang
Bhojpur
Terhathum
Panchthar
Parsa
Bara
Rautahat
Sarlahi
Mahottari
Dhanusha
Siraha
Saptari
Udaipur
Dhankuta
Sunsari
Morang
Ilam
Jhapa
Projects Under Construction
Projects Under Investigation Planning
District Boarder
Anchal Boarder
National Boarder