6. Grandwater Potential of Kingdom of Bhutan

GROUND WATER POTENTIAL OF THE KINGDOM OF BHUTAN

(Fact Finding Mission)

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SURFACE WATER

From the rainfall data it is possible to say that about 11[illegible]mm is the average rainfall and most of the rainfall goes as a surface run off (76%) whereas, about 5% retained in snow and rest 19% percolates as ground water (see river hydrographs). The low and high flow difference is not much ie 10 to 16 times unlike the other himalayan river, where it is in the order of 100 to 500 times.

River gauging was done for a limited period and also in the few rivers which does not provide good picture. However Bhutan posses the river gauge data of some of the major rivers (table..8........) from 1956 on ward which if converted into discharge will be a major asset in water resources planning for hydropower,irrigation and other development.Even if the cross section and discharge are not available,it will possible to utilise the above data by making one or two years observations at the same sites from where the data were collected and correlating the staff gauge height with the discharge.However a rough estimate of discharge can be made from the data of rivers of other regions.

Though discharge of a river at any point is related to cross sectional area and average velocity but it can be correlated withstaff guage to reduce the frequency of observation and computation of cross section and velocity.Whereas in the absence of any data of velocity and cross section the guage height data becomes less useful and in such case whatever is estimated may have ± 50%.However it is possible to correlate with similar environmental himalayan rivers data which is given below.

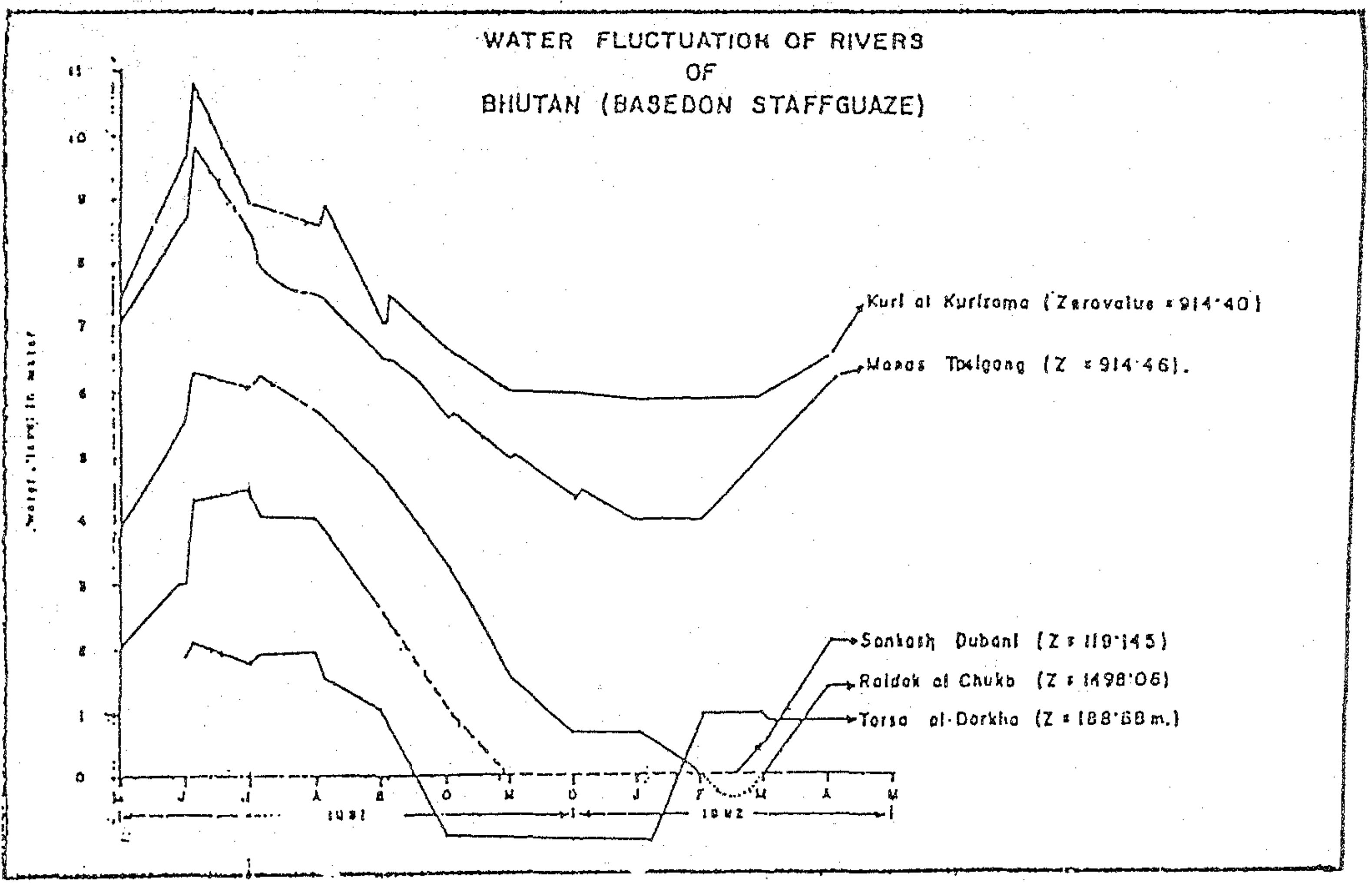
The relationship is averaged as shown below in the table and may be tested in case of Bhutanese river of which guage height is given in attached table no.8.&.Fig 5

STAFF GAUGING OF RIVERS OF BHUTAN. Table 8

	Torsa Dorokha	Kurlat Kurizamu	Raidak Chukha	Sankosh Dubani	Sankosh Wangdipho	Tongsa Mangdechhu	Manas Tashigang	Chamkarchu Bumtang
Zero								
Value M				0901				
mtr	100.65	914.40	1490.26	497.0	119.145	557.15	914.40	-
Jun	0.7-1.9	7.35-9.7	3.70-5.55	2.0-3.0	1.20-4.10	6.6-7.02	7.05-8.65	=
Jul	2.05-1.8	10.74-0.93	6.35-6.10	4.35-4.50	4.10-3.40	7.99-8.17	9.05-8.59	-
Aug	1.05-2.0	8.9-0.66	6.25-5.70	4.10-4.00	3.5-2.1	7.98-7.50	8.1-7.60	
Sep	1.5-1.05	8.93-6.75	5.65-4.75	3.90-2.50	2.3-1.2	7.46-6.96	7.55-6.55	
Oct	1.05-0.7	7.6-6.75	4.60-3.30	X	1.30-0.43	6.94-6.37	6.55-5.6	
Nov	m-.7	6.65-6.1	3.30-1.50	1-0	3.43-0.31	6.36-6.06	5.65-5.0	
Dec	m-.70	6.1-6.04	1.50-0.7	X	0.31-0.25	6.06-5.92	5-4.45	4.72-4.60
			19	82				
Jan	m-0.70	6.04-5.99	0.7-0.7	0-0	0.24-0.21	5.92-5.81	4.5-4.15	4.70-4.60
Feb	m-0.70	5.99-5.94	0.71-0.15	0-0	0.21-0.19	X	4.15-4.10	4.61-4.60
Mar	1-1	5.94-6.06	X	0-0.50	0.19-0.20	5.81-6.81	4.15-5.25	4.61-4.61
Apr	0.95-0.7	6.06-6.6	0.15-1.45	X	0.21-0.15	5.99-6.15	5.30-6.35	4.63-4.66

* M means minus below Zero
* all readings are in meters.

FIG. 5



WATER FLUCTUATION OF RIVERS
OF
BHUTAN (BASEDON STAFFGUAZE)

Rivers	Max v m/s	Min v m/s	G.H.max m	G,H. min m	Discharge m^3/sec max	Discharge m^3/sec min
a.Karnali	3.41	0.52	4.09	0.85	1848	94.82
b.Bagmati						
at Chobar	2.90	0.41	10.12	1.69	504	00.257
c.Sunkoshi						
at Khurkot	3.57	0.46	6.89	1.12	2786	84.23
d.Tamur	4.16	0.46	5.04	2.17	16.42	54.06
			26.14	6.03	6780	233.9

1. Maximum discharge per meter gauge height = $260m^3/s$.
2. Minimum " " " " " = $38m^3/s$.

Water and Power Potential:-

It appears that Bhutan's net contribution of water to the Brahmputra system will be 0.8(run off coefecient) x1.15(annual precipitation) to the river system which means annual discharge of Bhutan river will be $47000\times10^6\times1.15\times0.8=43240$ million cubic meter which is compatible to total run off as given by Dr.K.L.Rao(..1979.*.....) to Sankosh 17270 million and Manas 32000 to the point of Brahmputra. In his data a large part of India is also included. (See fig 6,7,&8)
(*Dr.K.L.Rao-India's Water Wealth P 267 Orient Longmen Ltd.)
According to Bhim Subba Executive engineer electricity Department, the low flow of Manas is 200 cu mec,Sankosh is 50 to 75 cumec and Chukha is 28 cumec.As low flow and high flow is 16 times difference the average will be approximetly 5 times of low flow.That means 1000 cumec for the river Manas and 375 for Sankosh and 140 Raidak.The total may be 1515 cumec.If other rivers are also taken into account and the total average discharge of 1717x.8=1373 cumec may be possible.This is really comparable with Nepal which has 5000 cumec with nearly 3 times area that of Bhutan. Bhutan has more rainfall in the foot hill region whereas,Nepal has higher rainfall all over midland.The above discharge theoritically can be converted in to electric energy $\frac{1373}{2}\times3333\times9.81=22446$mw

FIG.6.

FLOW DIAGRAM OF THE BRAHMAPUTRA RIVER IN INDIA AND BANGLADESH

NOT TO SCALE

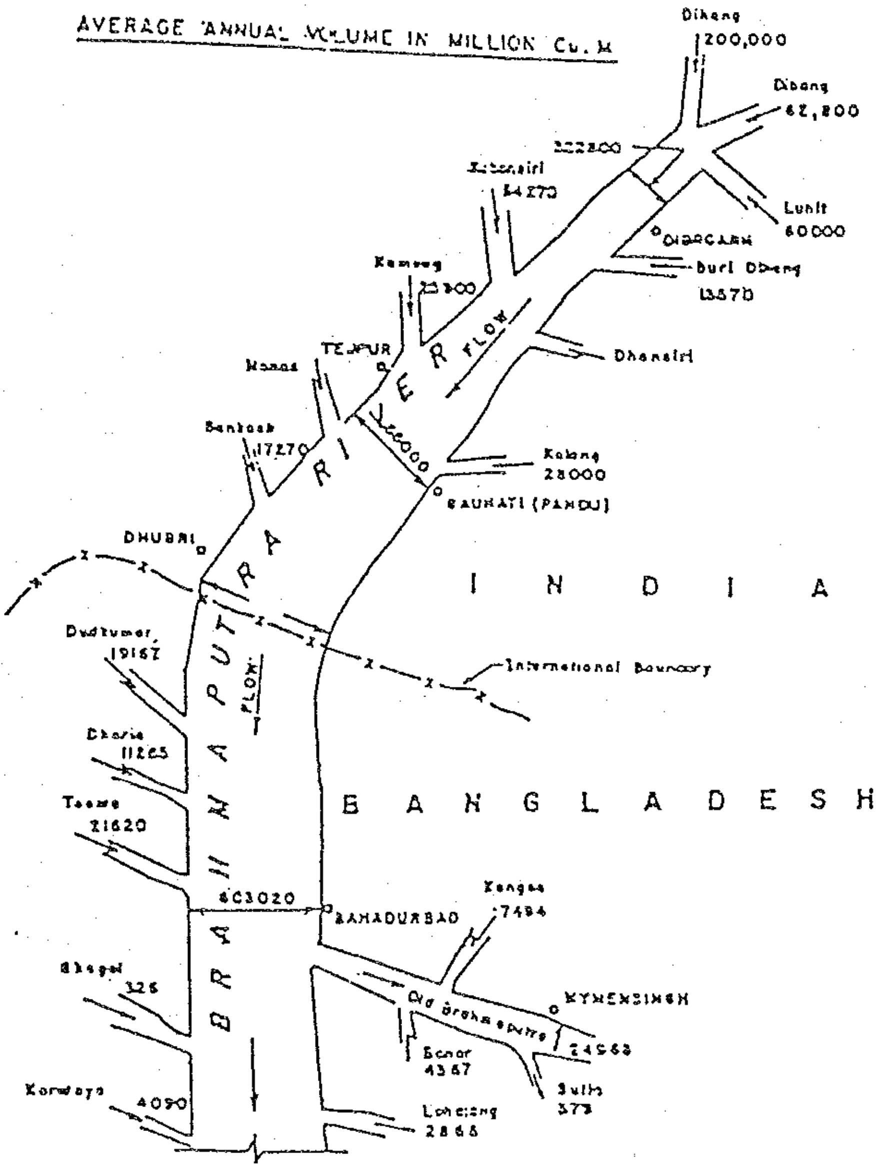
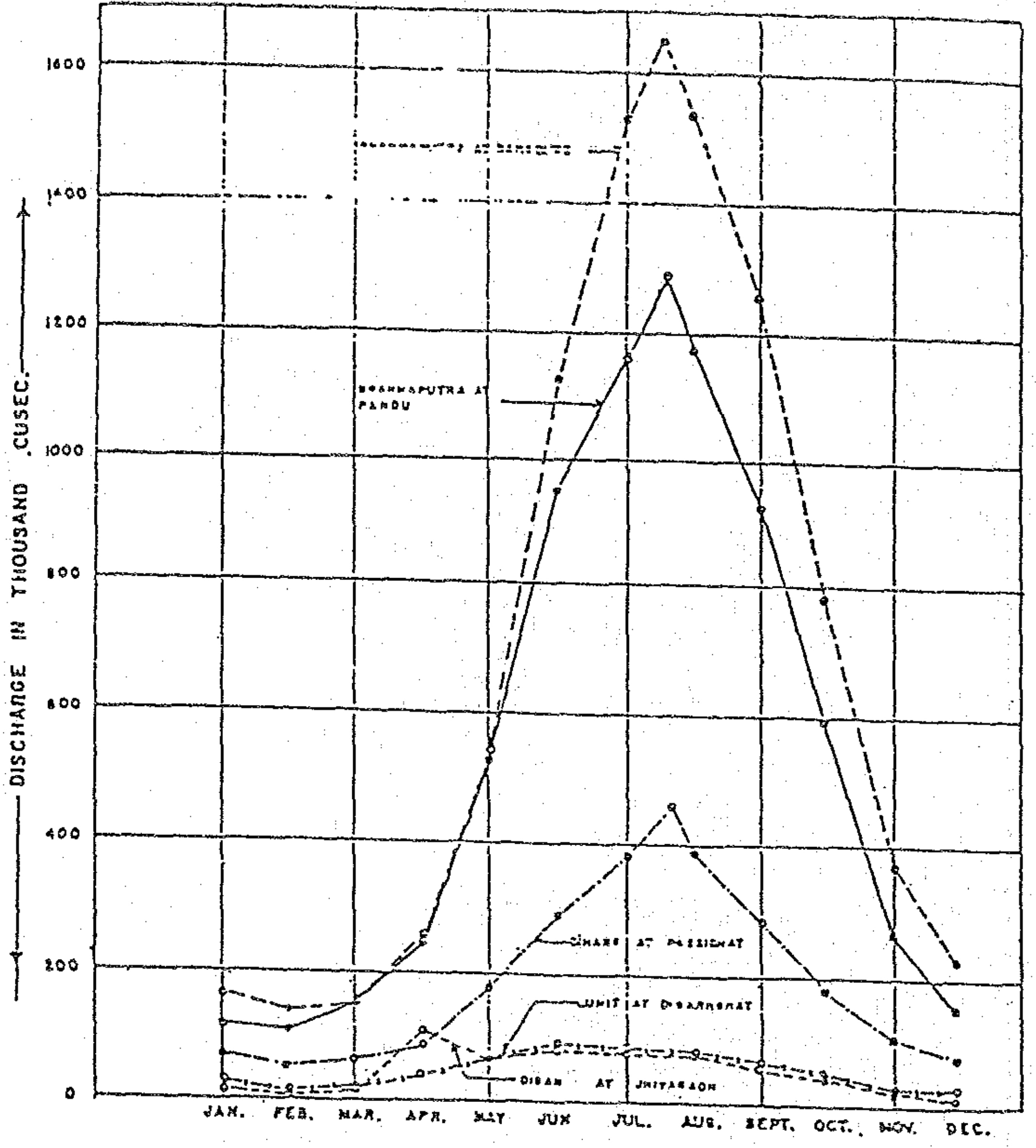

AVERAGE ANNUAL VOLUME IN MILLION Cu. M
Dihang
200,000
Dibang
62,800
Lohit
60000
222800
Subansiri
54270
DIBRUGARH
Burhi Dihing
13570
Kameng
23800
Dhansiri
TEZPUR
Manas
Sankosh
17270
Kolong
28000
GAUHATI (PANDU)
FLOW
RIVER
BRAHMAPUTRA
DHUBRI
INDIA
Dudkumar
19167
International Boundary
Dharla
11265
Teesta
21620
BANGLADESH
603020
BAHADURABAD
Kangsa
7494
Ghagot
326
MYMENSINGH
Old Brahmaputra
24563
Banar
4367
Sutia
373
Karatoya
4090
Lohajang
2868

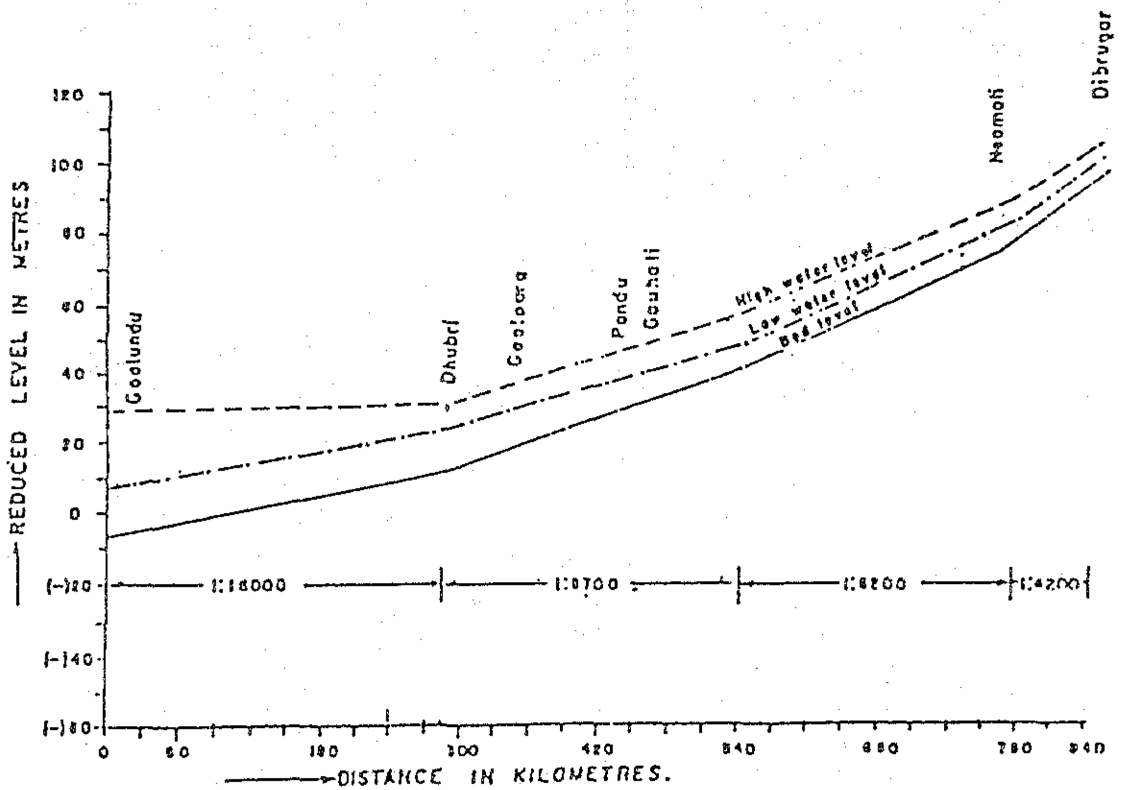
FIG.7



Average monthly discharge hydrograph of the Brahmaputra.

FIG.8

LONGITUDINAL SECTION



Bed slope of the Brahmaputra river from Dibrugarh to Goalundu.

On the basis of elevation and porbable discharge the figures appear to be as follows:-

Zone	Q 3	H	G	Energy
1. 400mm	144/sc	3355	9.8	4.7×10^6 kw
2. 800mm	228	2745	" "	7.75×10^6 "
3. 1500mm	332	1525	" "	5.00×10^6 "
4. 2500mm	297	915	" "	2.07×10^6 "
5. 3750mm	225	305	" "	0.07×10^6 "
				20.9×10^6=21000mw.

The above theoritical energy can be broken down as below:-

a. Basin energy inclusive of surface flow = 21000mw.
b. Energy of concentrated river courses = 14000mw.
c. Technically feasible 43% of a = 6020mw.
d. Continous energy 14% of a = 2000mw.

From the above analysis it can be said that commercially feasible energy of Bhutan lies near about 4000mw, which comes 20% of total theoritical potential (21,000mw). As Bhutan will not be able to consume this large block of hydropower in foreseeable future, it is possible to export to neighbouring countries for economic benefit.

The nature of rivers are streight and valleys are deep and narrow which is suitable for runoff type of river schemes. As gradient is sharp ie 3000 meters in 200km ie 25 meter drop per km the area is not suitable for reservior schemes. Due to sharp gradient the river has volocity 0.6m sec to 3 meter/sec at different times in a year (see fig..11...)

Reservior area is limited only at the out let part in the foot hill region where rivers are flat and have wide valleys. This is true in case of the Manas and the Sankosh.

Rivers Systems of Bhutan:-

Rivers systems of Bhutan are important not only for water resources but also they have developed wide valleys in the head regions which have helped to flourish the Bhutanese culture and civilization. The important river valleys are Thimpu, Paro, Punakha, Ha, Bhumthang, Tashigang etc.

The main river system of Bhutan are following(from east to west):-

1. Nyera Amari
2. Dhensiri river
3. Manas or Gong Ri
4. Mao or Aie river
5. Sankosh or Tshangchu
6. Raidak or Wangchu
7. Amochu or Torsa river
8. Jiti river

INVENTORY OF RIVERS BASED UPON 1:250,000 scale Map

From East to West:-

Primary		Secondary and teritary	
1. Nyera Amari river	90km.	a. Dish Lal Nadi	20km
		b. Richhong Ri (Chenla Ri)	30km(Ri or Chu means river)
		c. no name	12km
Total length 90km			62km.
2. Dhansiri river	55km	a. Jumri(Chumchu)	22km
3. Manas or Gongri	110km	b. Kuri or Uri	12 "
		c. Gamrichu	50 "
		d. Kulong or Tashigayang chechu	60km
		i. Wohmung chu	28 "
		ii. Kurichu	75 "
		a. Bigger chu(Behlungchu)	38km
		e. Tongsa(Magden chu)	160"
		i. Bhumthang river (Murchhangu chu)	80km
		ii. Burgong chu	38km
		iii. Ranji gang chu	20km
		iv. Langte (Nechu)	45km

Subdivisions of 3E1 Bhumthang:-		Subdivisions of 3E18	
a. Teng chu	42km	a. Mela chu	20km
b. Chamkhar (Chamokha chu)	32km	b. Chakoe chu	20km
Total	74km	Total	40km

Total 110, 360, 292, 129.

4. Mao (Aie river22km)
a. no name 12km
b. Gokechu 20km
(Gong khola)
c. Tirkhola 16km
Total 22km
Total 50km

. Between Mao & Manas a. no name 20km

. Sankosh(Tshangchu)105km.

a. Dagnachu 50km
  i.no name 15km.
b. Changchu Khola 20km
c. Burichu 33km.
  i.Larechu 20km.
d. Mochu 40km
  i.no name 10km.
e. Shaongchu 45km
f. Phochu 57km.
  i.no name (N-E of Phobijika) 22km
  ii.no name(W of Lunana) 35km
  iii.no name(E of Lunana) 15km
g. Punakha(Mochu)65km.
  i.no name(E of Nora) 12km
  ii.no name(W of Gasa) 22km
  iii.no name(S of Gasa) 17km

P= 105km S=350 T= 173

Raidak river (Wangchu)	125km.	a. Pipingchu	32km.	i. no name	22km (Shari)
				ii. no name	17km(S of Drugeldzor
		b. Ha Chu	55km.		
		c. Parochu	70km.	i. no name	17km.
		d. Thimpu Chu	37km		
		e. no name	22km (south of Thimpu)		
	125km.		166km		34km.
Amochu(Torsa river)	85km.	a. no name	35km (near Dungna)		
		b. no name	25km (" ")		
	85km		60km		
iti river	18km.				
0.no name(near Kopche)	15km.				

rand total length:-

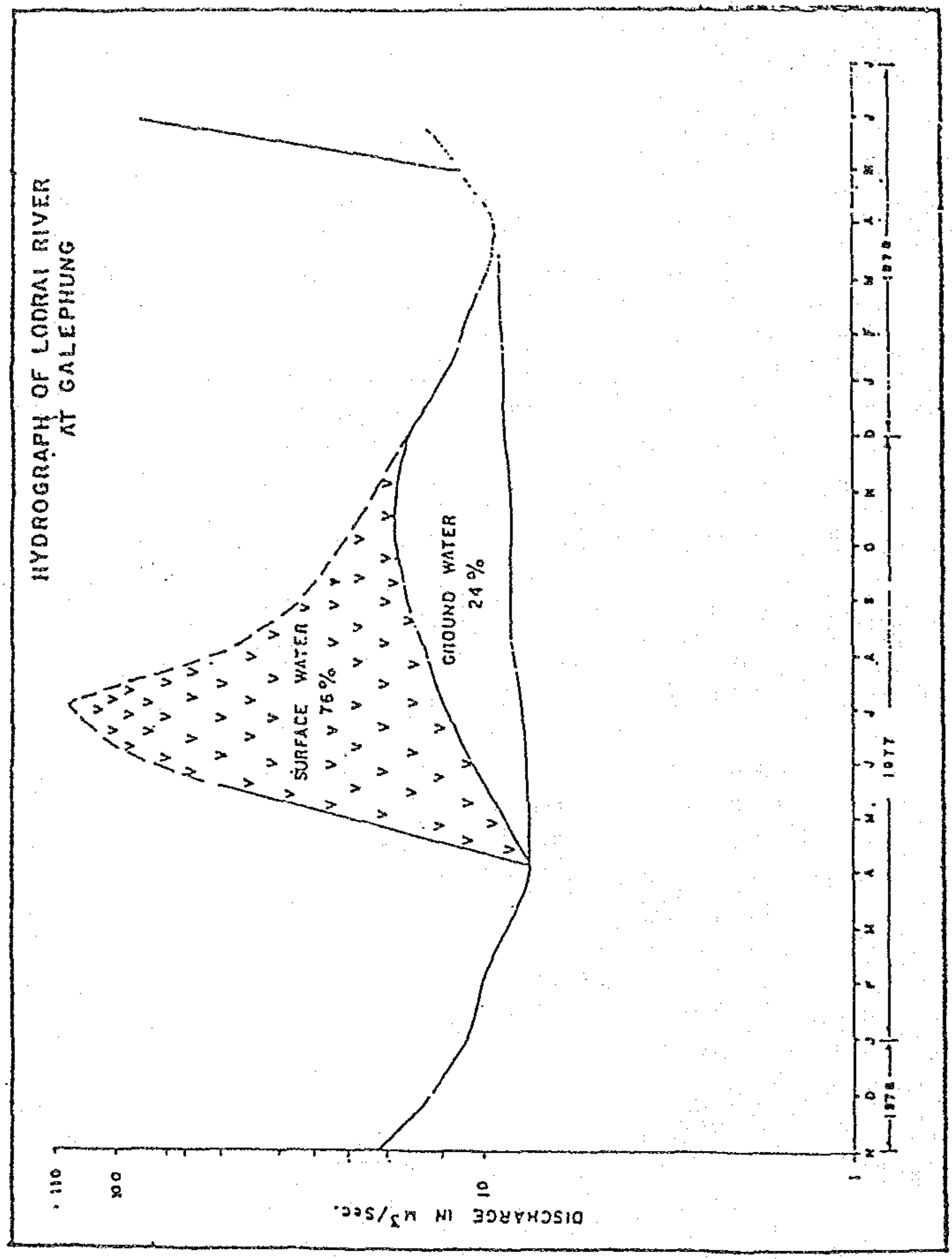
Primary	Secondary
654km.	998km.

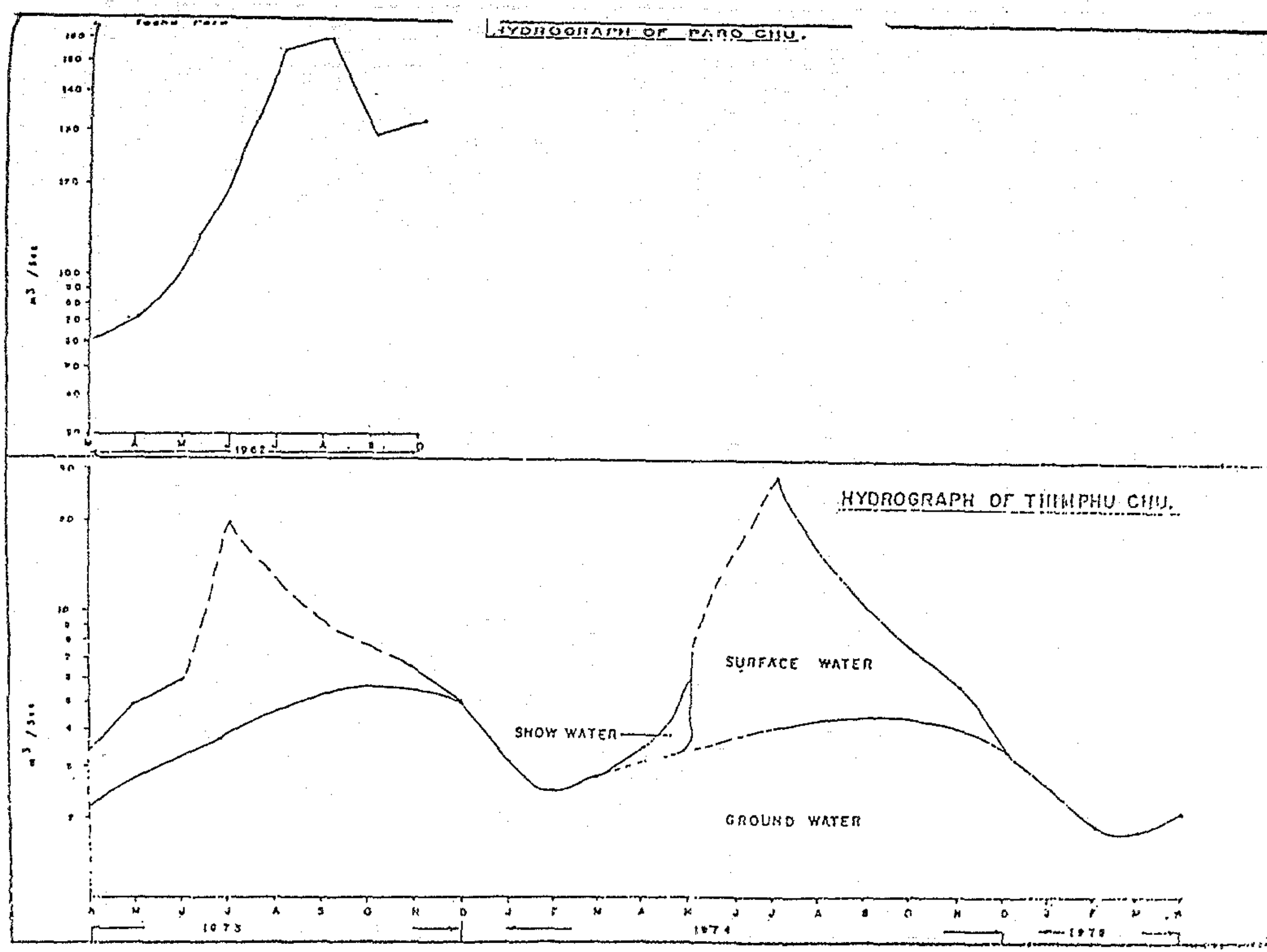
he above figure indicates that the 72.80 sq.,km.,is covered by per ,length of primary river if secondery is included it comes to .60 sq.,km.,.This indicates that the topography is hard and density primary river is 0.0132 which is less as compared to rivers of pal,as shown in the following table:-

w fed river			Non snow fed river	
Sunkosh	0:0165	1.	Kankai	0.068
Arun	0.0150	2.	Kamala	0.054
Tamur	0.0335	3.	Bagmati	0.045
Kaligandaki	0.0260	4.	Babai	0.058
Karnali	0.016227	5.	Jimruk	0.075
		6.	West Rapti	0.0395

ut of the above rivers the most important are the Manas,the Sunkosh he Raidak and the Amochu or Torsa.Only the Torsa river rises in the ibet whereas rest originate in the southern part of Himalayas of hutan.Except the Manas and the Sankosh all the rivers flow towards outh east of Bhutanese territory whereas,the Manas and the Sunkosh

FIG.9


HYDROGRAPH OF LODRAI RIVER
AT GALEPHUNG
SURFACE WATER
76%
GROUND WATER
24%
DISCHARGE IN M³/Sec.
110
100
10
1
N
D
J
F
M
A
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J
1976
1977
1978

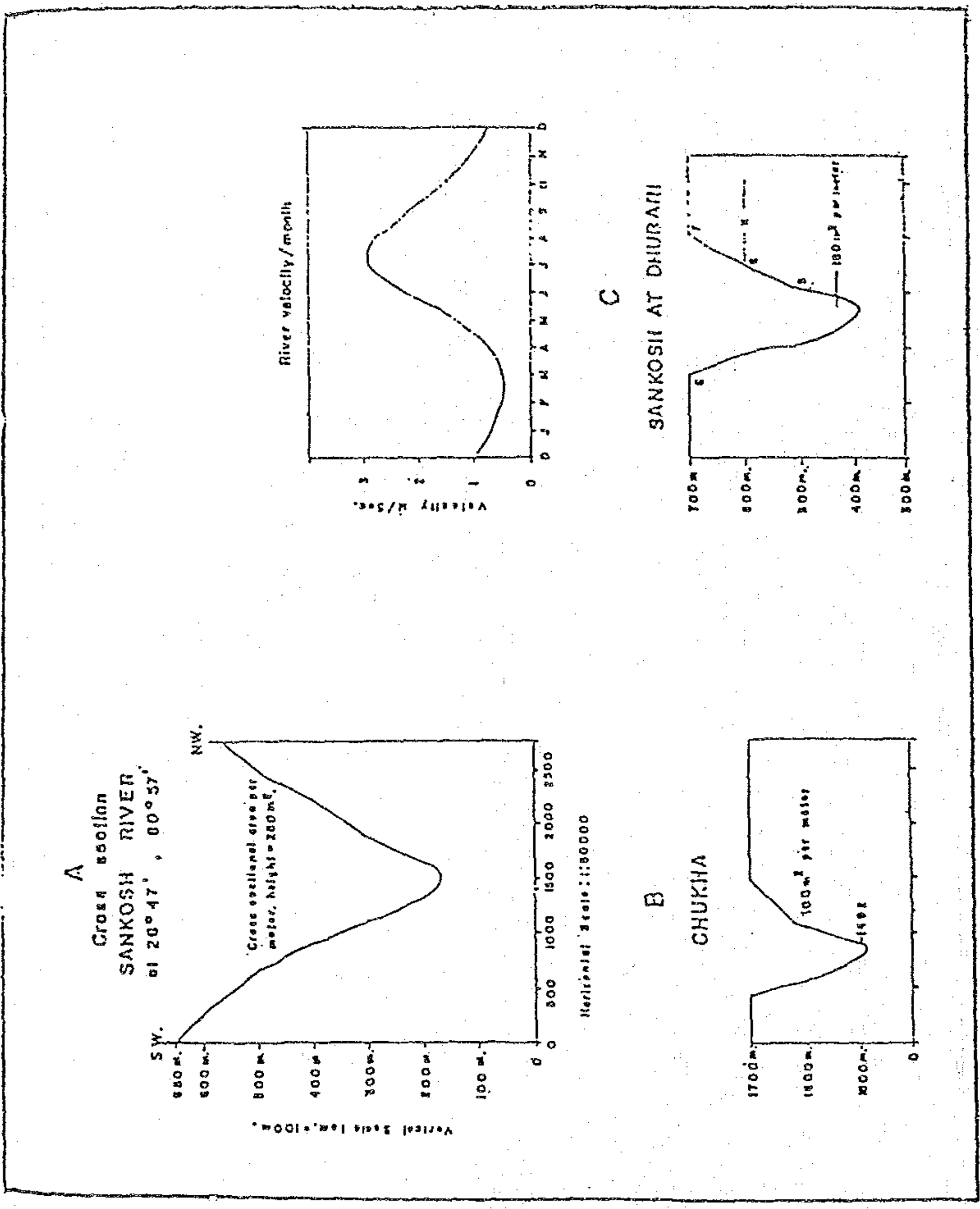


HYDROGRAPH OF PARO CHU.

HYDROGRAPH OF THIMPHU CHU.

FIG.10

FIG. 11


A
Cross section
SANKOSH RIVER
at 20°47' , 00°57'
SW.
NW.
Cross sectional area per meter, height = 250 m².
650 m.
600 m.
500 m.
400 m.
300 m.
200 m.
100 m.
0
500
1000
1500
2000
2500
Horizontal Scale 1:50000
Vertical Scale 1 cm. = 100 m.
River velocity/month
Velocity M/Sec.
3
2
1
0
O
J
F
M
A
M
J
J
A
S
O
N
D
C
SANKOSH AT DHURAHI
180 m² per meter
700 m.
600 m.
500 m.
400 m.
300 m.
B
CHUKHA
100 m² per meter
1700 m.
1600 m.
1500 m.
0

flows towards the south west. The catchment areas of rivers are cover with the forest and hard rock with the result, the sediment transport and erosion are limited The hydrograph of the Brahmputra indicates the ratio of low to high flow in neerly 10 times at Pandu (upper reaches) and 12 times at Bahadurbad (lower reaches).Like wise rivers of Bhutan will behave in similar fashion as that of the Brahmputra.

This characteristics is seen in the rivers of Bhutan which have low and high flow ratio 16 to 30 times and this helps much in the water resources development without reservior system.

These rivers also recharge the ground water equifers in the foot hill region and are also fed by ground water system in the hills.It is bserved that from the nature of river hydrograph contribution to the low flow by ground water is more significant as compared to snow melt. However,the rain fall being spread all over the year has also helped much in reducing the rigorasity of the rivers,ie flood in rainy season and low flow in the summer.If immediate rain fall part is deducted the ground water contribution becomes smaller to the river.

These rivers have developed terraces in the foot hill regions whereas, in the mountains except in upper reaches the river terraces are very few.There appears two old river terrace at Paro and at Thimpu and the river terraces are sloping towards the river.The discharge and other characteristic of some of the rivers are given in table at the end (Annexe nd represented in Hydrograph Fig 9 to 11.

Utilisation:-

At present Bhutan is importing electricity for the southern belt from adjoining part of India.However Bhutan has also developed many mini and micro hydro plants.

1. Power:-

a. Mini Hydro plant:-

Gita com	1.25 Mw.
Thimpu	0.36 "
Paro	0.40 "
Wangdiphodrang	0.30 "
Tashigang	0.75 "
Mongar	0.35 "
	3.45 "

On the top of the above generation, nearly 1315.5×10^6 kwh is purchased annually from India.

b. Major plant:-

A big hydroelectric at Chukka is on its way to completion. In th first phase the capacity is 4x84me=336me operating under a head of 466m. A 40 meter high gravity type diversion dam and head race tunnel of 6.5km long and 4.9m diameter, surge shaft 12m dia and two presure shafts of each 3m diameter will generate power in under ground power station. The estimated cost is about US$ 187 to 250 million.

2. Irrigation:-

In irrigation sector much had been done particularly in the hill and lift irrigation system.

The following is a list of irrigation coverage in different districts. The cost of lift irrigation is becoming expensive as cost of electricity is about 60 paise per unit.

	District	Total command area	
1.	Thimpu	5045 acres hill area	
2.	Paro	414	
3.	Haa	100	
4.	Punakha	451	
5.	Wangdi Phodrang	2247	
6.	Gasa	nil	
7.	Tongsa	122	
8.	Bhumthang	nil	
9.	Shemgang	404	
10.	Daga	393	
11.	Tashigang	5480	
12.	Pema Gyel shel	130	
13.	Mongar	500	
14.	Luntshi	1245.5	
15.	Phunsoling	4745	southern zone
16.	Galephung	7320	lift irrigation
17.	Chirang	203	
18.	Samdrup Jonkar	1540	
		31370.5 acres.	

In the above hill irrigation schemes, generally the idle length of canal is at present 6 to 7 km and may be 10 to 12 km in future schemes. One lift irrigation is seen in Galephung area.

The details are as follows:-

1. No of intakes 3 (Two are operating)
2. No of pumps 2 (one will be added)
3. Capacity 20 cusec
4. Lift 17 meter
5. Length of main canal 6.85km.
6. Length of distributaries 21km.
7. Capacity 20 cusec up to 2.5 and 25 cusec beyond
8. Command area 2000 acres
9. Requirement of water 20 cusec

In the second stage the lift will be about 121 meter,

3. Drinking Water:-

For centuries people lived either near the river or walked several kilometers to fetch the water. Now many areas are under piped supply tapping surface water. Piped drinking water is supplied in most of the district head quarters of Bhutan. Samdrup Jonker has a well and lift arrangement to supply water. Except limited area there appears to be no problem of drinking water.

By 1980, 150 units of rural and 26 in the urban water supply schemes were completed and now nearly 48 schemes are in progress in the rural parts of Bhutan.

GROUND WATER

The hard and impervious rocks of the hills are not suitable for percolation and storage of ground water except in the weak and faulted zones which help as a secondary porosity to preserve the ground water.Most of the springs from where the water is now supplied either for irrigation or drinking water,are located in the fractured zones.A systematic survey of such weak zones with springs will help Bhutan not only in the selection and identification of cheap drinking water projects but also for drilling in hard rock to tap the most of the spring water.In valleys like Thimpu and Paro nearly 18m gravel deposits are found in the mid part valley.At present the surface water and springs are found to be sufficient in hills not to warrant the ground water development.

In plain area the drinking water is a problem at Pagli,Samdrup Jonkar and Phunsoling where water is supplied for two times a day.It becomes acute during the summer when most of the rivers dry up. In irrigation sector,during Feburary and March the small supply from contour canals also,dries up and this creates problem for 2nd.,crop even though sometimes there are scattered showers of rain.For third crop there is always a problem.

To have assurred round the year irrigation as well as to supply drinking and indudtrial water,Bhutan Govt.,has shown interest in the search and the development of the ground water.

The ground water is a part of hydrologic cycle and influenced by the rock system.It is necessary to analyse each of parameters like rain fall,surface water,rock and terrain.

The following are the conclusions derived from the study of various physical parameters, discussed in earlier chapters.

Bhutan has ample rain fall and the rain fall is spread practically round the year hence additional water requirment will be little to meet the evapotranspiration need,which varies from place to place but can be estimated 1 meter in total.The total rain fall figure varies from 1800 to 5441mm,which if refined in course of time will give a better picture.To be on sefer side the available rain fall is assumed to be above 1152mm and may be around 3000mm per annum in specific places.

Rocksin the hills are unfavourable for ground water storage except in valleys where at present there is sufficient water which if required can be lifted up.

As Bhutan is covered nearly 70% of land surface by various types of forest,she is fortunate to have very few land slides as compared to other part of Himalayas,but rivers are becoming wild and rivers training in Paro and other places are now essential.As hard rocks covers most of the area in hills the agriculture is done only in the valleys.In areas where soft rock has been found,people have cultivated and irrigated by contour canal and in few years time they have lost their entire field due to slides.(This feature is seen near the bridge at Sarbhang).

Topographic analysis:-

Bhutan has limited plain and more slopy area at the foot hill, suitable for irrigation and agriculture development,consequently the requirement of the ground water will be small.

From topographic maps the following areas are found to be reasonably sloping for agriculture development and from general analysis suitable for ground water investigation and development.

	Name of the area	Size of the area	Elevation	Name of near by river
1.	Nainital	1.5x3km	(gradient) 400-500, 1:5	Chung Patan Perenial
2.	Chengmari	1x2.5km	320-440(1:11)	Diana perenial
3.	Samchi	4x4.4	300-480 (1:3)	Chamarchi river (perenial)
4.	Gokti (near cement Factory)	1x0.5	280-320 (1:25)	Suktinadi (seasonal)
5.	Pagli	2.05	340-400(1:33)	Pagli nadi(seasona

n the north of the area a highly dense and steep topography is bserved whereas, the southern area which falls in India has more moother contours. Near by peaks in the north have elevation 632m, 36m, 1120m, 879m, 962m, respectively. (see Fig. 12).

pography analysis indicates that better prospects exists in Pagli kti and Samchi area and unfavourable in Changmari and Kainital.

FS

Phunsoling	1x0.7	200-240(1:25)	Dute Khola& Torsa perenial.
Kali Khola	2x1.5	420-440(1:50)	Kali Khola
		440-700(1:4)	perenial

ary steep topography and flat area are found in the north and outh respectively. The terrace is 6 to 16km high from the river ed at Phunsoling whereas, at Kali khola terrace level is 45m levation on the average.

he nearest peak at Kali khola is 1019m. In Phunsoling area ground ter potential exists in lower part at Indo-Bhutan border.

J

Sematung	3x0,7	300-320 (1:25)	Tungkhola
		320-360 (1:10)	Perenial
Kawal Tar	1.5x1.5	300-400 (1:15)	Shistikhola pernial

J/13

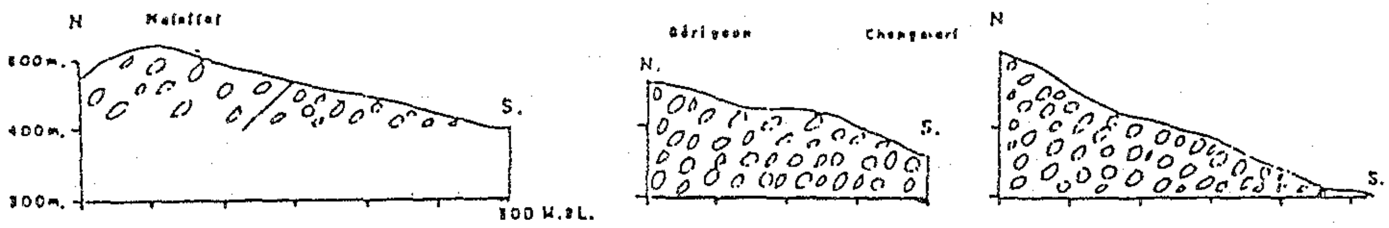
Area between Dysa nadi to Gobar kund nadi	14x2	200-300 (1:20)	Gobar kund area
		280-360 (1:25)	Dysanadi area

In this area the symptom of recharge is seen as the river goes under ground from a reasonable distance. In Gobar kund aree the terrace is 50m., above the river bed whereas, it is 6 to 6m., above river bed, at the Dysanadi area. Though this area is under the forest, it may be cleared in future if more agriculture land is needed, as it has better potential for ground water.

FIG.12

CROSS SECTION OF TERRAIN

Scale — [1 cm = 0.5 Km. horizontal / 1 cm = 100 m. Vertical.]


N
Malaffat
500m.
400m.
300m.
S.
300 M.S.L.
Gérigeon
Changmeri
N.
S.
N
S.

1. The Manas river is 200 to 300m.,wide at the out let part in Bhutan. There is a terrace 1.5x1km.,which has elevation from 180 to 200m. This area may be good for lift irrigation

Map 78/I

1. Charphuli to Suti Nadi 7x2km.,100-200 (1:2)

South east of the area in the Indian territory three spring line lakes were observed.They are Kohal [illegible]ri bil ,Chanmari bil and Dhel dhela bil.The Rabang nadi gains water and Charphuli nadi loses water indicating ground water recharge.The river bed is 12 meter below the land surface.North of.Charphuli area the terrain is steep and the elevation ranges from 987 to 1082m.In the south flat land and dense forest area (with broad leaved tree and 3 meter high elephant grass) are found.

78N/5

Only the western part has some flat area of 300 to 400m.,elevation, where the river gains and loses water indicating ground water system working in that area.The northern part has relatively flat conrours and elevation is 1066 meter.

78N/9

Samdrup Jonkar has flat terrace and the elevation varies 180 to 200m.The available area is 0.5x1.5m.Development site for the ground water appears in the central part of the area.In the north hills have bad land topographic feature like Siwalik rocks in other parts of himalayas.The rivers are perenial and lose and gain water.

The course of Sarnadi has terrace all along for distance of 9km., on either side.The terrace lies at 6 to 12 meter above the river bed and the elevation of terrace is 180 to 220m.,on the average.

78K/13

ala para flat area 0.5x1km 200 to 240m.

1. In this area, it is found that the river loses water in India. The southern part in India has a flat land with forest and tall grasses.

2. Between the Chamrang Nadi and th Kalapani Nadi a comparatively flat area of 280-380m., elevation is seen. This size of the area is 3x1km., and gradient is 1:12. The Chamrang nadi loses water in India.

3. Some flat area of 340 to 360 elevation are found at Khirkhria near the Kampajuli nadi. Near by river loses water just above the terrace and gains water down below, indicating that ground water recharge and discharge are occurring.

4. Conclusions:-

1. From the above study it is seen that the south eastern part of Bhutan has comparatively better chance for ground water development than the west. However limited areas in the west also can be developed under the ground water.

2. In this study some of the forest area has been included, as Bhutan has limited agriculture land, the area under forest where water resources seems to be adequate may be converted in the future in to agriculture land.

3. Surface water and ground water needs to be augumented for the conjunctive use, in order to balance the slide problem as well as to increase the command area in the low flow season of the river when water is required utmost for agriculture and domestic uses. In mucnicipaluse also ground water can be pumped directly without any treatment which will finally help in financial savings.

TYPICAL SECTION

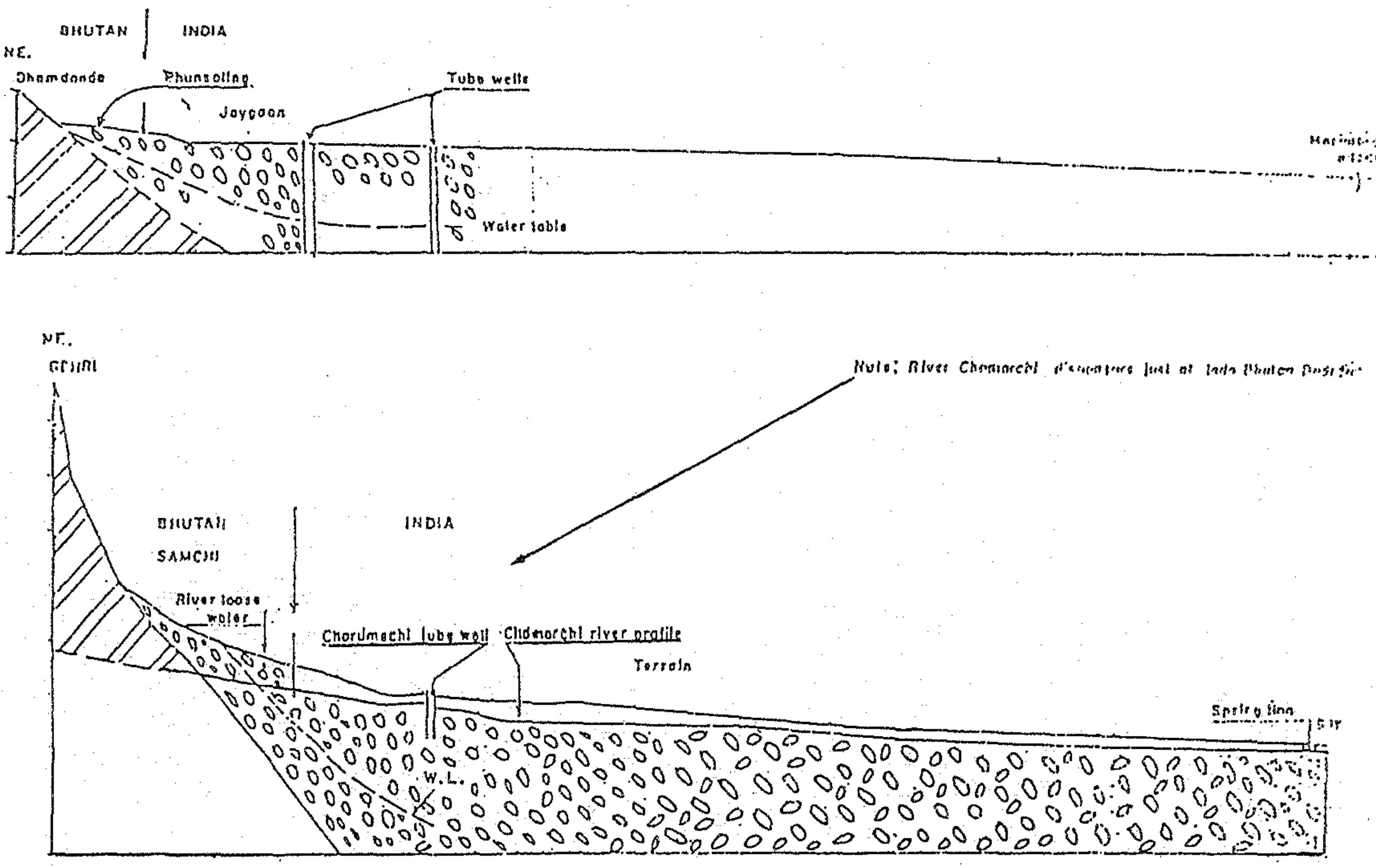
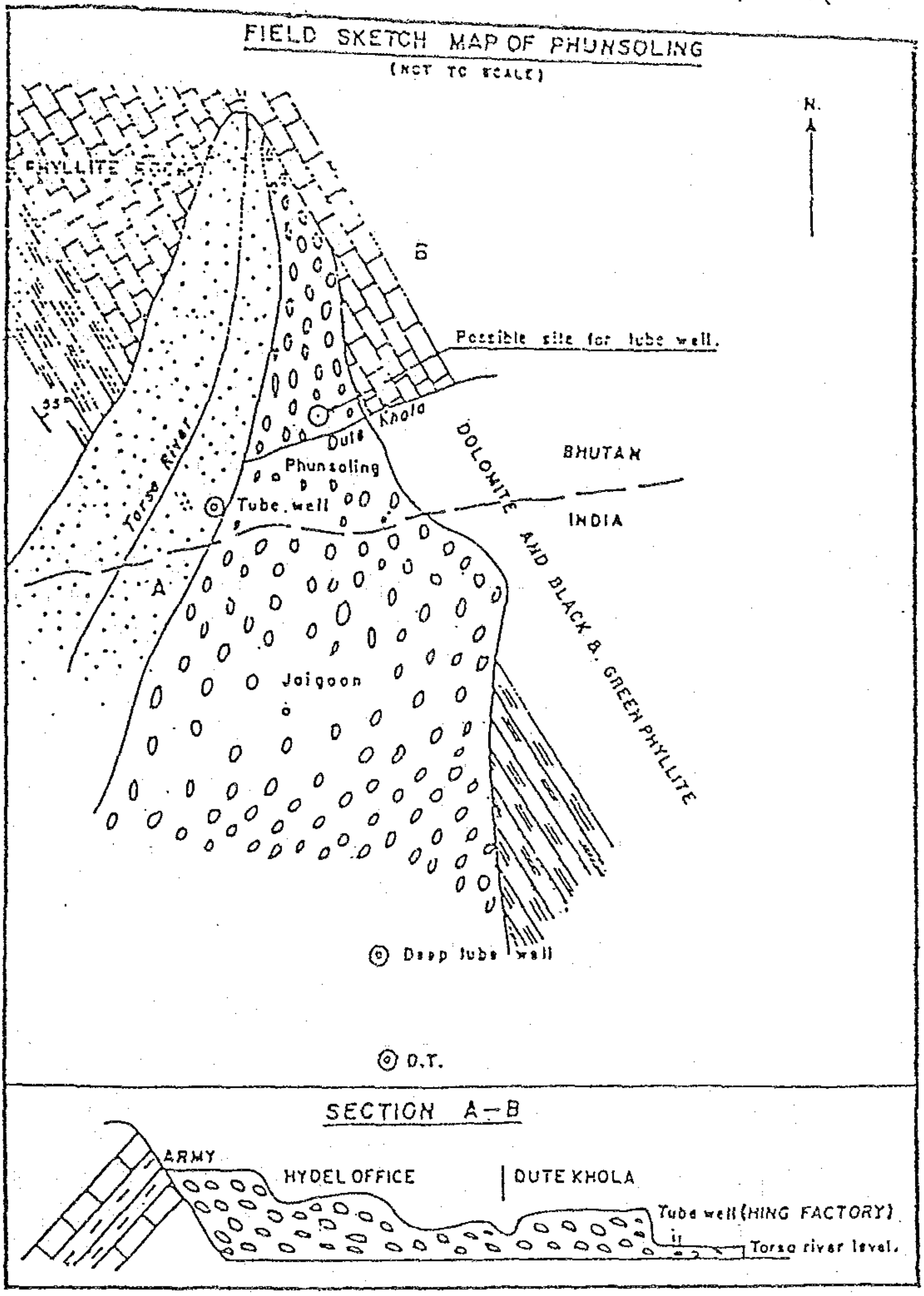

BHUTAN
INDIA
NE.
Dhamdande
Phunsoling
Jaygaon
Tube wells
Water table
NE.
GEHRI
BHUTAN
SAMCHI
INDIA
River loose water
Chorumachi tube well
Chamarchi river profile
Terrain
Spring line
5 M
W.L.
Note; River Chamarchi disappears just at Indo Bhutan Border

FIG. 13

FIG. 14



FIELD SKETCH MAP OF PHUNSOLING
(NOT TO SCALE)

N.
PHYLLITE ROCK
B
Possible site for tube well.
55
Dute Khola
Phunsoling
Torsa River
Tube. well
BHUTAN
INDIA
DOLOMITE AND BLACK & GREEN PHYLLITE
A
Jaigaon
Deep tube well
D.T.
SECTION A—B
ARMY
HYDEL OFFICE
DUTE KHOLA
Tube well (HING FACTORY)
Torsa river level.

Regional geological picture indicates that the alluvium deposit at the northern flank of the Brahmaputra river will be order of 250 meters minimum as the rivers like the Raidak the Sankosh and the Manas have respectively 40m,30m,70m,60m, elevation from M.S.L. at the junctions of the Brahmputra.If a trough fault like in the Gangetic plain is proved in that case the thickness of alluvium will be several 1000 meters.Hydrograph of the Brahmputra river impress that the contribution by the ground water is reasonably high and will spread.

FIELD OBSERVATIONS

Phunsoling Area:-

Geomorphologically the area is a notch inside the hill and hill go far south of Bhutan to India making a delta shape area in Bhutan. Phunsoling area has three levels of old terraces above the present river bed.From present river bed level of the Torsa,the first terrace is 3 meter high and second terrace is about 10 meter high where the office of Chukha hydel department is located.The upper most terrace where Army office is located is also nearly 10m., above the second.

The terrace consists of boulder gravel and sand in unsorted form and work as a recharge zone.Hing factory made 1m diameter dug well upto 11m depth in the river bed and is supplying the water to the factory.There is no dug well even in the Jaygaon area of India.Norgam Cinema hall area appears to be ideal site for first test well in Phunsoling.

The sketch map of Phunsoling is given in the fig..13.&.14On investigation it is found that West Bengal Govt.,has recently drilled one tube well south of Jayagaon and another is in progress.

The deteils are as follows:-

Test tube well:-

Totel depth drilled	282' by precussion method.
Size of the well	10"163'
Size " " "	6"119'
Screen zone	165'
Water level	150'

Strata log:-

0-60'	Boulders
60-180	clay sand etc.

2nd., tube well is located nearly 1km.,south of the first well

Strata:-

0-3	top soil etc
30-90	heavy boulder
90-102	coarse sand with clay
102-120	clay with coarse sand
120-140	coarse sand and clay
140-156	coarse sand with gravel
156-160	Yellow sticky clay (marker horizon)
160-175	coarse and medium to fine sand
175-180	yellow sticky clay
180-240	coarse sand
240-	drilling in progress

water level 140 feet.

Duration of drilling 2 to 3 months for a tube well.

On the basis of above data,it can be said that the gravel deposit in Phunsoling extends to greater depth and appears to be faulted block which may provide good aquifers.The depth of water table may be little bit lower than India ie 150 feet.With in a depth of 250 feet th ee groups of aqufers (one phreatic,two confined may be found.

Ghumaune area:-

In Ghumaune area the terrain slowly raises and finally on the top of the hill, a forest area is found. The soil is red coly apparently weatherd, phyllite. In the Ghumaune area several dug wells are found. They are located at the following places

Forest department.

Lakshman Chetri well.

Lower terrace.

At India near Bhutan boarder.

The dug well of the Forest department is located in a gully and is nearly 3 feet in diameter. The water level was at 30' below the surface in July 1982. The well is 75 feet deep and is said to dry up in the summer.

Nearly 30 feet below, in the same line practically at the gully Mr. Lakshman Chetri dug a 10 feet diameter well and depth was 70 feet and water table is nearly 5 feet below the surface and this well does not dry in the summer.

In the same line practically 100 meter (330 feet) below a dug well is found near Indo-Bhutan boarder on the east of the road which is also 3 feet in diameter and depth is unknoum and remins as it is in summer ie water table is nearly at the surface.

Follow ng the same slope coming to Indian territory, a dug well of 3 feet diameter and 32 feet deep is found where the water level stands at 20 feet and in summer it reaches to 28 feet ie 8 feet fluctuation. While digging they found gravel and boulders. It appears that the same aquifer which is sloping with the terrace is found in that area and like wise there may be deep aquifer.

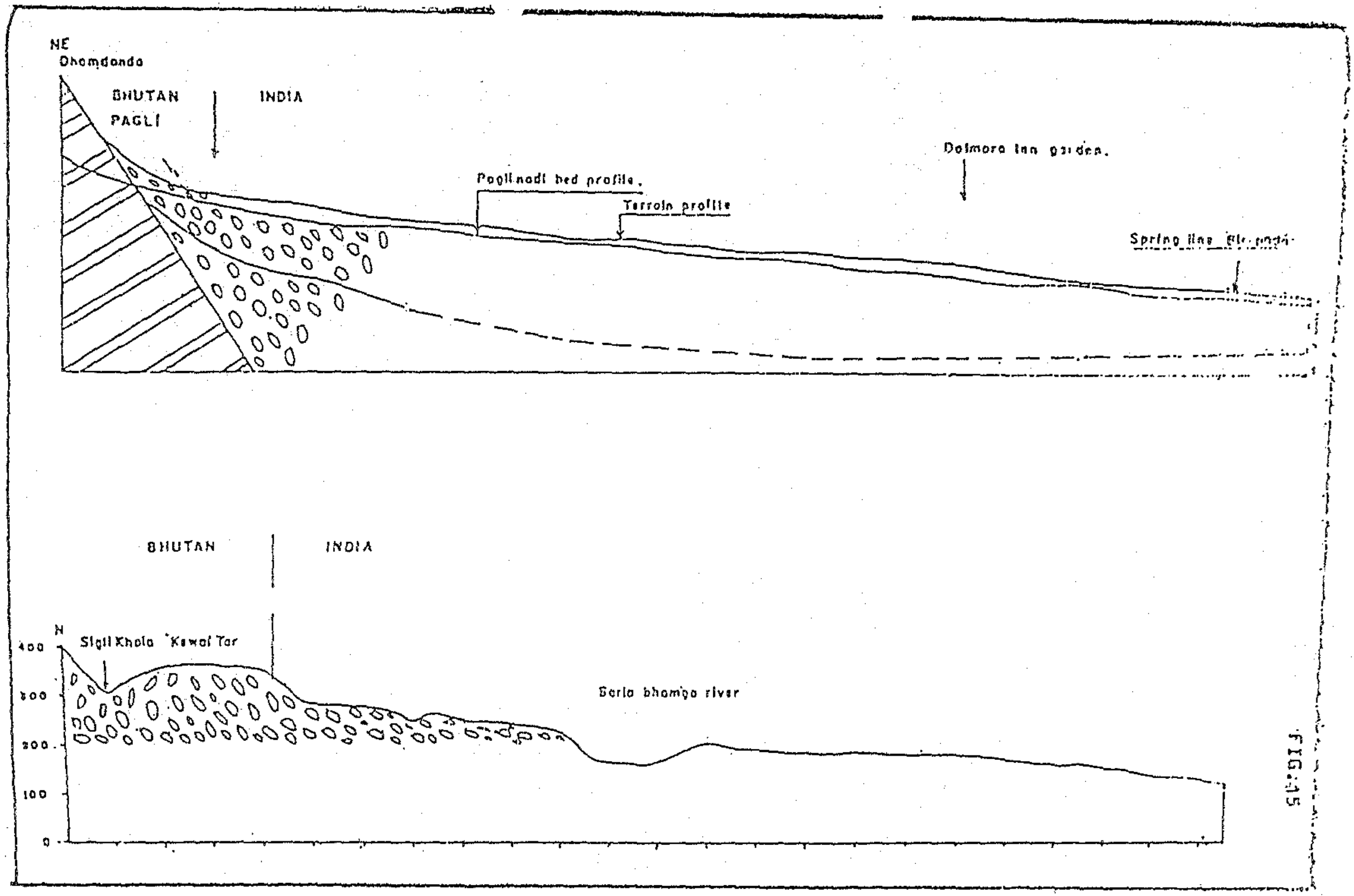
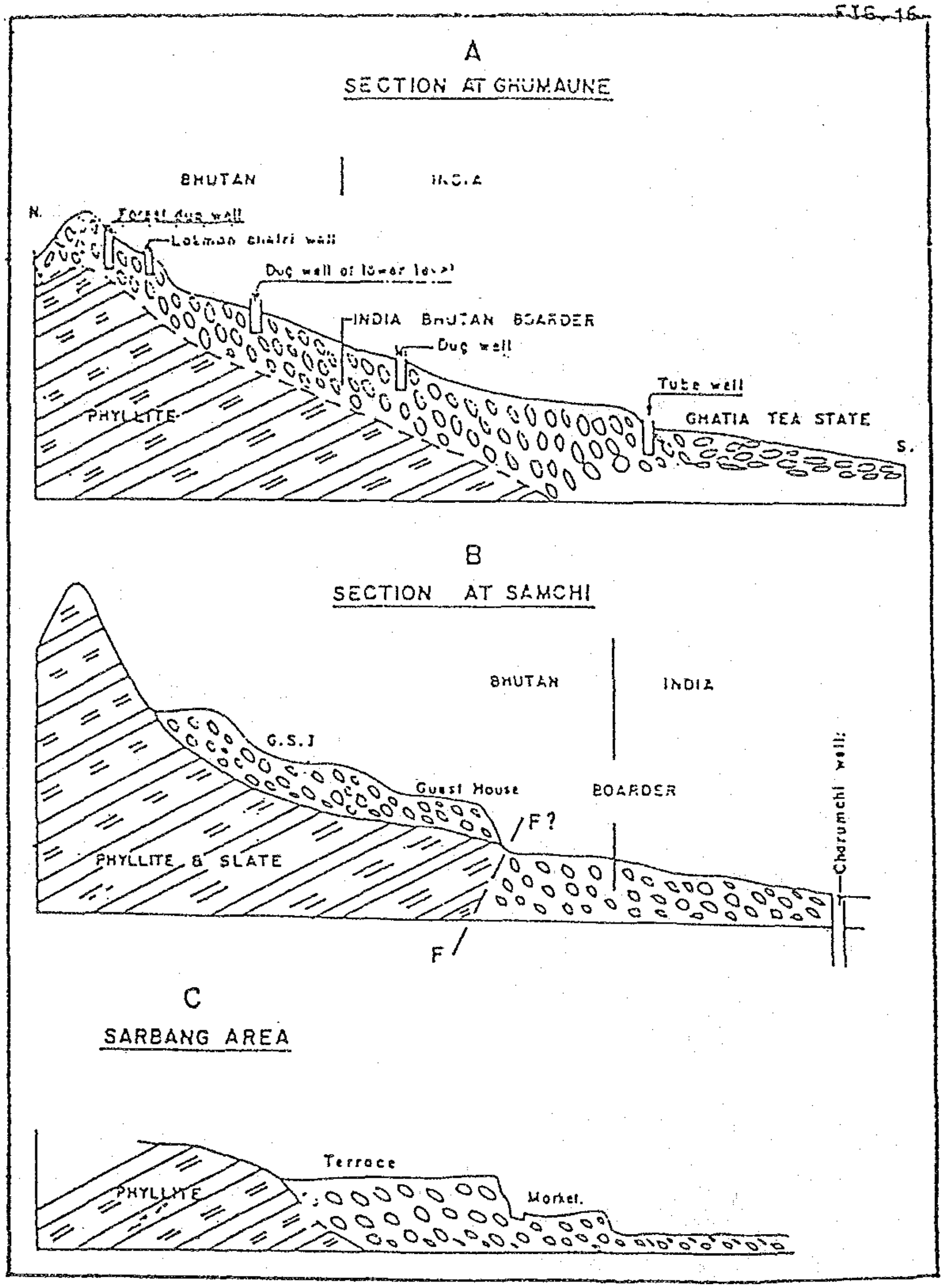

NE
Dhomdanda
BHUTAN
PAGLI
INDIA
Daimara tea garden.
Paglinadi bed profile.
Terrain profile
Spring line [illegible]
BHUTAN
INDIA
N
Sigli Khola
Kewai Tar
Sarla bhamga river
400
300
200
100
0

FIG. 15

FIG. 16



A

SECTION AT GHUMAUNE

B

SECTION AT SAMCHI

C

SARBANG AREA

BHUTAN
INDIA
N.
Forest dug wall
Lokman chatri wall
Dug well of lower level
INDIA BHUTAN BOARDER
Dug well
Tube well
PHYLLITE
GHATIA TEA STATE
S.
BHUTAN
INDIA
G.S.I
Guest House
BOARDER
F ?
F
PHYLLITE & SLATE
Charumchi well
Terrace
PHYLLITE
Market

C. Samchi area

In Samchi area there are four levels terraces

1. Bhutan boarder zone
2. Market
3. Guest house
4. Geological survey of India compound

In Samchi for the drinking water piped water supply comes from a stream in the north and they do not have problem of drinking water. The terraces are covered with 10 feet layer of boulders and below it lies the basement rock of phyllite. Irrigation is being done by means of contour canal in the lower terrace of Bhutan boarder zone. The agriculture farm of 15 hectars located in the lower zone does not have sufficient water and a tube well can be drilled for them. The well will encounter boulder and sand horizons. Two kms., south of Bhutan boarder at Charmuchi a well was drilled by West Bengal Govt., and the available details of the wells are as follows

Size of the well	10"x6"
Drilling depth	350'
Water level	265'
Depression	5' after 5000Gpm.
Sp.yield	1000G per foot

They have installed a 36 BHP motor and it is said it took six months to the contractor to drill that well.

D. Pendent Cement Factory Area:-

Pendent cement factory (Bhutan Govt., undertaking) is located at the foot part of the hill in the east of Samchi. There most of the rivers are dry and water is tapped from the hill. In this area one deep well can be tested. (see fig. 15 & 16)

E. To Pagli:-

Between Pendent cement factory and Pagli village, most of the rivers are dry and topography of the area is smooth. Rivers are aggrading and guide bunds to protect Pagli are now found to be buried in the river bed. Water is supplied from stream in hills through pipe. There a tube well can be drilled but the problem is river aggradation which if not controlled will cover the entire agriculture land with boulder within few years. Engineering and geological solutions have to be found to control the rivers. At Bir Pada (India) which is nearly 15km south the spring line has been noted.

F. Galephung area:-

Compared to other foot hill part of Bhutan, Galephung have smooth topography and wide terrace. The terrace consists of boulder and gravel. No well has been drilled in this area. At present for town and some of villages and also for Sarbhang water is supplied from the hills. For irrigation a lift irrigation from the river Lodrai is developed to command 2000 acres with water duty 20 cusec. The capacity of pumps is 20x2=40 cusec which in the low flow season is unable to meet the demand.

Near Galephung in India territory people tried to dig a well and they went upto a depth of 50' and finally they had abandoned due to financial problem and boulder. Nearly 10km south of Bhutan boarder a dug well is found at the check post of Deosiri in India. The well is 3 feet in diameter and water table was 20 feet from surface (August 1982). From the above observation it is possible to drill several wells in Galephung area and water table may be order of 180 feet (estimated).

G. Sarbhang and Chirang area:-

Five kilo-meter east of Sarbang near Akhaw a spring well constructed by Dantak while constructing the road was located. It is said that the well never dries up.

Sarbhang valley consist of pebble and boulders of slates and phyllite.The requirement of drinking water for the population terrace in the eastern part of Sarbhang,is met by the piped on the water.The rock dip 40^{0} due north near the bridge.Sarbhang has enough water from Sarbhang river as well as from its tributary to meet the agriculture need.The main problem is of slides and aggradation of the river.

Between Sarbhang and Dampu (Chirang valley) lies a hill which consists of lead grey phyllite at the base and then a thick well bedded and possibly repeated white quartzite which has produced several interesting high head water falls by the side of road on the way to Chirang.On the top lies micaceous schist and gneiss which are found to weather into red clay. At Damphu,water is supplied by piped water supply.For the future requirement a tube well can be drilled in the fractured zone.

H. Samdrup Jonkar:-

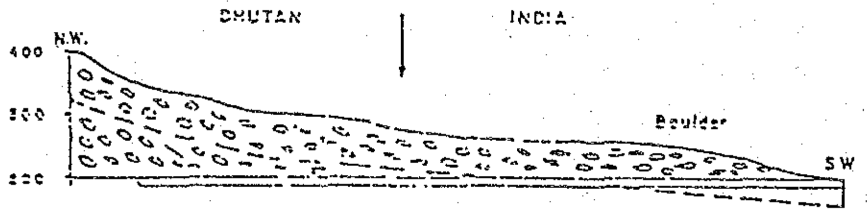
The area rises sharply and very limited area lies in Bhutan.For the drinking the piped water is supplied in some of the parts where as a large well 10 feet diameter is constructed in the river bed from where the water is lifted for the town, There are terraces in the area.The dug wells are found at the following places

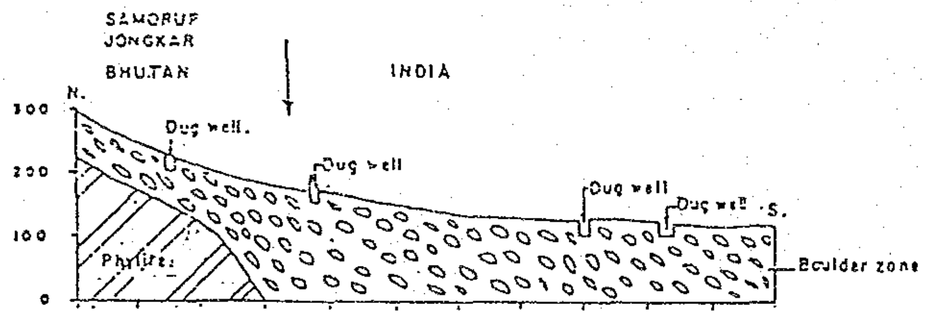
1. Market area (Ratanlal well 1960)
2. Kunfan Mills area
3. Hospital

In the area two dug wells are found one at the check post of Bhutan and other in India near Bhutan boarder.The water table is near to the surface and the well is nearly 2 meter deep and never dries up.It is located in the spring line as most of the rocks at the base are in sand stone and the shale dipping north.

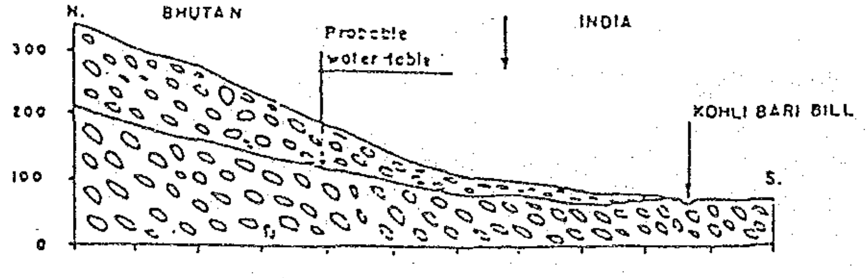
FIG. 17

SECTION WEST OF GOBAR KUNDANDI


BHUTAN
INDIA
N.W.
400
300
200
Boulder
SW


SAMDRUP
JONGKAR
BHUTAN
INDIA
N.
300
200
100
0
Dug well.
Dug well
Dug well
Dug well
S.
Phyllites
Boulder zone

EAST OF GARUCHANADI


N.
BHUTAN
INDIA
Probable
water table
KOHLI BARI BILL
S.
300
200
100
0

In Indian boarder they have tapped the well at drainage point and the water table is near to the surface.

At Kunfen mill the gravel is found abutting the Siwalik rock.A small well of 30 feet deep was dug where the water level was found at 5 feet below the ground and it is said that it does not dry up in the summer months.

The hospital building is located on the Siwalik clay formation and a well was dug which started intercepting the sewage of septic tank and later on it was abandoned.

In south of Samdrup Jonkar,in India numerous dug wells are observed. As Siwalik dips north below the upper terrace sediment,well in Siwalik sand stone may bear ground water.(see fig: 17)

Over all Analysis:-

A critical analysis of the available data of surface water ie the hydrograph of the Lodrai river and water level fluctuation data of all the major rivers,lead to conclude that about 19 to 23 of the total river flow is contributed by the ground water system.The total flow is 58385 million^3,the ground water share will be 11717 million m^3.If converted in to daily discharge it will be order of 372 cumec.

In practice about 50% of the above can be tapped from a series of tube wells.However,this will lead to the depletion of base flow of the rivers,but at the same time there will be reduction in high flow by recharging of the reservior.

In the mountainous part,besides th using of the streams the ground water also can be tapped to augument the surface water in order to meet the domestic and agriculture needs.As ground water has uniform quality and temperature round the year,this will help not only in water supply but also in industry where uniform temperature and quality can be an asset.

More over Bhutan has numerous hot springs scattered in the northern zone. They need to be investigated fully for their commerical uses as well as for tourist industry. The geothermal energy can be used in room heating as well as in other energy replacement sectors, which could be exploited to Bhutan's benefit.

The aquifers in hill region consists of fractured dolomite quartizite and other faulted zones which provide enough secondary porosity for ground water percolation and retention. In selected area such zones can be tapped to meet the local demand of ground water. Fortunately, Bhutan has built roads all over the regions and have developed electricity in most of the districts it will not be difficult to ke the drilling rig and install pumps in those places.

In mountain valleys like Thimpu, Wangdiphodrang and Paro, the lift irrigation and tapping of mountain streams may meet the present demand of water, however for the future it will be advisable to have inventories of all the streams and ground water potentials of different regions.

Exploitations of the ground water in mountains of Bhutan may have the following benefits:-

Temperature moderation in colder places.
Industries where chemically treated water is not advisable
ike beer and other processing units
hen supply line is too long and expensive.

t present the Royal Government of Bhutan is interested to know the round water resources of southern foot hill region, particularly. his also supports the view of consultant who feels that it is asier to start from the south and gradually cover the mountainous rea in later phases when Bhutanese nationals are competent to carry ut the developmental work by themselves.

The southern Bhutan has anple rain fall and geology of foot hill and terrace indicates that at least 25 to 50% of the rain fall percolates dowm as a recharge to aquifer which comes out as a spring in far south in the Indian territory.

The fluctuation of water table at Ghumaone and Samdrup Jonkar indicate suceptibility of aquifer system to react with the condition.Wells drilled in the adjoining parts of India indicate that theterrace material goes below the surface for several hundered feet,suggesting a faulted zone on the northern flank of Brahmputra valley which may be similar to Indo gangetic plain where thethickness of alluvium deposits amount to not less than 5000 feet at several places.If this is also proved by:series of drill holes, a new concept will come for development of ground water of Bhutan.Along with geological test holes,geophysical and pump testing of wells will definitely add new data and ideas for further development.Finally addition of data will help in better planning of the resources.The permeable nature of boulder and gravel at the foot hill region suggests that this area adjacent to the foot hill is a recharge zone for phreatic as well as semiconfined aquifer system of the northern plain of the Brahmputra river.This assumption is further reinforced by other evidence.

Firstly this is an area of high rain fall,secondly the available water level in the dug wells and resulting pattern suggest flow from this formation out ward.Thirdly the fluctuation of water level in the dug well indicates at least more efficient recharge there than further down in India.The foot hill boulder and gravel grade into other finer sediment further south.

These all features indicate that transmissivity may be order of 1000,00 to 4000,00 gp d/per foot in this region which is comparable to Bhabhar zone of Nepal.

This area can only be drilled by percussion machine and it may take 2 to 3 months to complete a well.As there is enough recharge the water quality will be good.

7.　新聞記事（1989年8月5日付，インド援助）

Kuensel Aug. 5. 89

Agricultural development for Geylegphug

An agreement reached : Dasho C. Dorji with Mr. N. Dayal

Bhutan and India signed a Nu. 51.570 million agreement for the Geylegphug Integrated Area Development Project.

The project, to be started in 1989-90 for a five-year period, will emphasise on agricultural development with an allocation of Nu. 41.164 million. The balance of Nu. 10.406 million will be spent on the development of livestock and poultry.

The project is aimed at increasing food production, the income, and the living standard of the people.

About 2558 acres of land will be *brought under irrigation*, apart from improving existing *irrigational channels* which cover about 2700 acres.

The Bhur Agricultural Research Station will be developed and upgraded to a regional station with better extension *training programmes* and seed multiplication. A pig and poultry breeding center will be set up at Sarbhang.

Since one of the major problems *faced by the farmers* is a shortage of money to buy agricultural inputs, the project will include an agricultural credit system.

Some of the other activities of the project are soil and land resource *assessment*, soil conservation, manure and compost sheds, development of *manpower and agricultural* extension facilities, establishment of a statistical cum information unit, and horticultural development.

Five consultants will come to Bhutan *through the project* to advise on areas like soil conservation, water management, and crops like *sugar* cane, rice, and oil seed.

In animal husbandry, the main objectives are to achieve self-sufficiency in milk and milk products, and *to raise the per capita income* of the farmer through improved livestock and increased production.

The agreement was signed on Thursday in Thimphu by the Indian Ambassador to Bhutan, Mr. Nareshwar Dayal, and the Deputy Minister *for Planning, Dasho C. Dorji.*

"Since cooperation was established between the two countries more than a quarter century ago," said Dasho C. Dorji. "Bhutan's economy has been transformed from a subsistence farming into a modern one. The past five years have been *most gratifying*, as many of the joint Indo-Bhutan projects like the east west highway have been completed."

"India stands committed to be a partner in Bhutan's development process, and this agreement is a part of that commitment," *said Mr. Dayal* who is at the tail end of his term in Bhutan.

According to Dasho Khandu Wangchuck, Director General in the Department of Agriculture, it has been the royal government's strategy in the Sixth Plan to identify and establish development projects. Geylegphug was chosen since it was suitable, because of existing infrastructure like the road network and the ability of the population to adapt to change.

A different experience

For Richard Snellen, the new *project officer for the local office of* the World Food Programme, Bhutan is a *big change from* his last station in Sudan. He calls it a "unique opportunity".

Caught in the middle of a civil war, Juba, where Snellen was stationed, was besieged *for two years. With* different factions stopping the food supplies, 250,000 people died of starvation, said Sneller.

UNICEF and WFP set up the "*Operation* Lifeline South Sudan" and delivered more than 60,000 tonnes *of food by June this year.*

Meanwhile for Bhutan, said Snellen, the *buffer stock of 1,750* metric tonnes of cereal - 300 mt of sugar and 100 mt of oil - is on its way. *This stock will be kept to tide over* any interruption in the supply of essential goods into the country.

A WFP sub office will soon be set up in *Phuntsholing* to help *FCB distribute food.*

The WFP also plans to combine the *school feeding project and the health* project. Supplies for the dairy plant, scheduled to be *commissioned* by November, was also well under way, he said.

JICA