

BLUE PRINT FOR GODAVARI RIVER WATER UTILIZATION IN ANDHRA PRADESH

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Abstract: This paper explains how the unutilized Godavari river water could be put to use fully for irrigation with the help of water powered pump units and pumped storage schemes without proposing inter state dam projects. This paper also proposes how the available water in Godavari and Krishna rivers could be used for irrigating most of upland areas in Telangana and Rayalaseema regions with optimum pumping power.

Godavari is the largest river of all peninsular rivers in India. It has a total drainage area of 312,812 square km of which 48.6% lies in Maharashtra, 23.8% in Andhra Pradesh (AP), 18.7% in Chattisgarh, 5.5% in Orissa, 2% in Madhya Pradesh (MP) and 1.4 % in Karnataka. Principal tributaries of Godavari are Pranhita, Indravati and Sabari. All these tributaries drain water from high rainfall areas (i.e. more than 100 cm annual rain fall) except the main river Godavari. These tributaries contribute 80% flow of the total river. The average yearly water flow in Godavari is nearly 110 billion cubic meters. Pranhita drains Vidarbha region and joins the main river near Kaleswaram temple town in AP at 95 meters Mean Sea Level (m MSL). Indravati traverses through parts of Orissa and southern part of Chattisgarh and joins main river upstream of proposed inter state dam project at Inchampalli in AP. Sabari drains from parts of Orissa and Chattisgarh and joins the main river upstream of proposed Polavaram dam in AP.

WATER AVAILABILITY:

The water available in the upper reaches of Godavari up to Pranhita tributary confluence are fully utilized by Maharashtra, Karnataka and AP by developing various irrigation projects. There is no reliable flow (75% dependable yield) available in the main river till its tributary Pranhita joins the Godavari. The Godavari river water utilization is governed by interstate agreements reached under “The Godavari Water Dispute Tribunal”. AP is permitted to utilize nearly 1495 TMC (Thousand Million Cubic feet) out of the 75% dependable yield, which is nearly 3565 TMC. AP has harnessed nearly 600 TMC till now. AP is contemplating to use rest of the water by constructing Inchampalli and Polavaram multipurpose projects. These projects enable the transfer of excess Godavari water to deficit areas in Krishna and Pennar river basins after meeting the Godavari basin requirements.

The water requirement and the ultimate irrigation potential in Godavari basin below Sri Ram Sagar Project and up to Polavaram dam are indicated in Table-1. The 75% and 50% dependable water availability data at Inchampalli dam site and Polavaram dam site are given in Table-2. From National Water Development Agency (NWDA) data given in Tables 1&2, substantial additional water at 50% dependability excluding the unutilized water by upper riparian states is also available in the river for use by AP for additional irrigation purpose. All this water is available during monsoon months whenever river is flooding. It is inevitable requirement to store this floodwater in storage reservoirs before putting to use round the year for irrigation. Also some carry forward storage is required to cope up with bad monsoon years. AP has to create at least 1000 TMC storage capacity additionally in Godavari basin to harness the available water fully.

Interstate Inchampalli project's reservoir is proposed with 10,374 million m³ gross storage capacity at Full Reservoir Level (FRL) 112.77 m MSL. This reservoir would submerge total 926 sq. km of land in Andhra Pradesh, Chattisgarh and Maharashtra states. Additionally Bhopalapatnam Hydro-electric (900 MW capacity) project, a joint project of Chattisgarh and Maharashtra states, is also envisaged with a gross storage capacity of 9,494 million m³ upstream of Inchampalli dam on Indravati. The stored water in Bhopalapatnam reservoir would be available at Inchampalli after generating hydro electricity.

State	Annual irrigation in hectares				Cultivable area in hectares	% of cultivable area	Annual Water Utilization (Million m ³)
	Existing Projects	Ongoing Projects	Proposed Projects	Total			
Maharashtra	389960	854809	1717577	2962346	4704574	62.97	19,843
Chattisgarh & MP	144054	352226	1278916	1775196	2765470	64.19	12,700
Andhra Pradesh	718677	69361	609061	1397099	2317151	60.29	10,949
Orissa	9489	239492	286391	535372	694293	77.11	4,049
Total	1262180	1515888	3891945	6670013	10481488	63.64	47,541

TABLE-1: Ultimate irrigation and annual water utilization in Godavari basin below Sri Ram Sagar Project up to Polavaram Dam site.

	Between Sri Ram Sagar dam & Inchampalli dam site (Million m ³)		Between Inchampalli dam site & Polavaram dam (Million m ³)	
	50% yield	75% yield	50% yield	75% yield
Gross annual yield	76,185	66,193	18984	14879
Surface water import	(+)4540	(+)4540	(+)1831	(+)1499
Surface water export	(-)5622	(-)5290	(-)652	(-)652
Total water availability	75103	65443	20163	15726
Irrigation requirement	40723	40723	5634	5634*
Domestic requirement	1753	1753	136	136
Industrial requirement	2718	2718	283	283
Evaporation loss	3387	3387	362	362
Total water requirement	(-)48581	(-)48581	(-)6415	(-)6415
Regeneration yield	(+)6291	(+)6291	(+)702	(+)702
Water availability	(+)32813	(+)23153	(+)14450	(+)10013

* 2521 is proposed for irrigation use in AP

TABLE-2: Water availability in Godavari river

CONSTRAINTS:

As per the inter state agreement for Inchampalli joint project, AP shall bear 78.1% cost of the dam, land & properties acquisition (including that of Maharashtra and Chattisgarh governments) and rehabilitation of all the displaced population but it can draw only 2265 million m³ (80 TMC) from the reservoir and develop & produce 27% of the hydropower. The only option left for AP is to plan lift irrigation projects by using water, which is released in to the river after utilizing for power generation. The interstate agreement is concluded without fixing the FRL of the reservoir. The agreed terms would be attractive to AP only incase the reservoir capacity is of the order of 1000 TMC. Inchampally site is very favorable to construct dam economically with nearly 1000 TMC storage capacity at FRL 125 m MSL. The river at this point covers nearly 80% of the total catchment's area with adequate water inflows. This is one of very few sites for locating huge storage reservoir in India similar to Aswan High dam (4600 TMC) in Egypt and lake Volta (4200 TMC) in Ghana. Inchampally reservoir with FRL 125 m MSL would incur very low cost per TMC water storage after meeting the land acquisition and rehabilitation costs at prevailing market rates.

However AP government has proposed FRL level 112.77 m MSL fearing some coal deposits would be submerged above this level. The delay in taking up this project is boon in disguise to AP. Presently in situ coalmine gasification technology is very well developed and in commercial use. This technology is used to exploit coal deposits located deep in the underground (600 meters depth & more), the abandoned under ground coal mines and also coal deposits located in seabed. The latest technology adopted from oil & gas wells drilling such as serpentine drilling / inseam drilling, guided drilling, bunching of wells, etc. has made in situ coal gasification technology a reliable and commercial proposition. With under ground coal gasification technology, the coal deposits, which got submerged under the reservoir water, can be exploited economically.

Maharashtra and Chattisgarh states are not agreeable to the Inchampally reservoir with FRL 112.77 m MSL fearing political problems. Nowadays, even minor inter state water dispute settlement is taking inordinate time till it is adjudicated by the highest court. In this situation, it is impossible to construct a major inter state irrigation project like Inchampally.

In these severe constraints, AP must consider alternate dam sites to store Godavari water. There are few dam sites in AP for constructing medium height dams (below 40 meters height) across Godavari as an alternative to Inchampally dam. One dam near Edira (geographic location 18°07'03" North and 80°43'09" East) is feasible with FRL at 95 m MSL and gross storage capacity of 250TMC. This reservoir would not submerge land (other than river bed) in Maharashtra and Chattisgarh states. The proposed down stream dam at Dummagudem can be merged with Edira dam with additional long tail race channel up to suitable tail water level. The merger of both dams will maximize the available water energy / head (50 to 45 MWC) for lift irrigation and also to reduce the construction cost.

WATER POWERED PUMP UNITS:

Most of the unirrigated land in Godavari basin of AP is situated above 95 m MSL. Lift irrigation schemes are to be implemented to supply water to these uplands from Godavari. Also pumping of water is required to transfer surplus water to adjacent Krishna basin. Conventional practice is to install electricity driven pump sets to pump water to the required level. Hydroelectric power stations are installed for meeting pumping electricity requirement and the pump sets are interconnected through electricity grid. Exorbitant investment is required in creating these facilities. The cost of pumping facilities can be reduced drastically by adopting novel solution “Water Powered Pump” (WPP) units. WPP unit is a hydro turbine coupled to water pump. These units are installed at the toe of the dam. The water released from the dam in to the river for downstream needs will drive the turbine of WPP unit. The shaft power generated by the turbine would drive the pump of WPP unit to lift water above the reservoir level. Thus water is (refer Figure-1) drawn from the reservoir and partly pumped to uplands by harnessing the energy of water that is let in to the down stream river. In case of electric pumping stations, first hydro electricity is generated and then used to drive the electric pumping station. WPP unit pumps water by utilizing water energy directly without taking recourse to electricity.

WPP unit is less costly than electric pumping stations since it is simple in construction, rugged and compact as it contains a hydro turbine connected by shaft to the pump. WPP units can be installed at the toe of the dam in submerged or buried conditions also with approach wells / shafts for operation and maintenance needs. Water conduits are to be laid from WPP unit to the high elevation point where water is to be released in to canal. WPP units including associated water conduits would cost less than electric pump units and also does not consume electricity unlike electric pump units. Thus substantial cost is reduced by avoiding separate hydroelectric power station, transmission lines, etc. to pump the water.

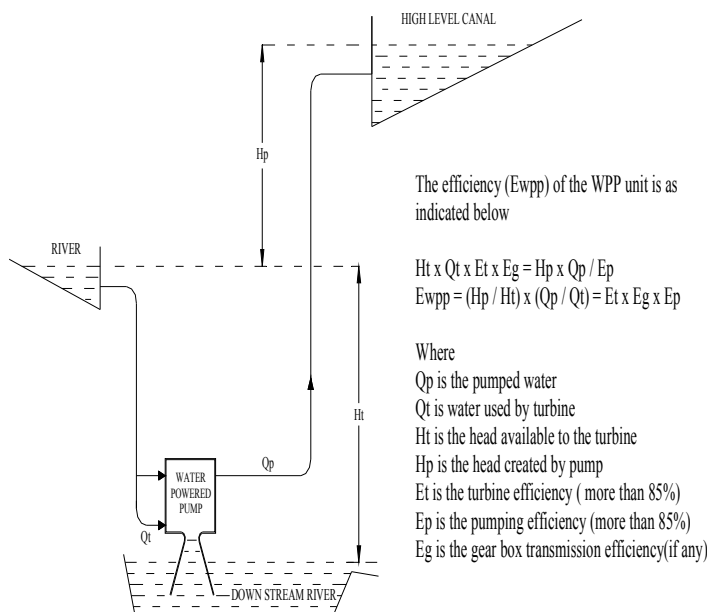


FIGURE-1- WATER POWERED PUMP UNIT

WPP units would qualify perfectly in harnessing the Godavari river water since substantial water is to be released from the dams in to the river for down stream requirements. Water is to be released for Polavaram requirements from Edira dam and Polavaram dam is to release water to the Dowlaiswaram barrage requirements. The lifting head required are in the range of 25 to 45 meters from these reservoirs to irrigate uplands in Godavari basin and to transfer water to Krishna basin. WPP units can become instrumental in complete harnessing of Godavari water allotted to AP and also its surplus floodwater at a faster pace economically.

Since WPP units are located at the toe of the dam, it can also utilize most of the un-silted dead storage water in the reservoir by meeting both downstream and upstream requirements. WPP units also maximize utilization of stored water obliterating the difference between live and dead storages. Nagarjuna Sagar reservoir has nearly 200 TMC dead storage below its canals sill level. If WPP units are installed at the toe of Nagarjuna Sagar dam, water can be supplied to both right and left bank canals by harnessing the energy of water released for Krishna barrage requirements. Nearly 150 TMC unused water storage of Nagarjuna Sagar up to 115 m MSL could be utilized with nominal additional investment. WPP units located at the toe of the Nagarjuna Sagar dam on either side can be connected at the required level to the reservoir with the technique called live reservoir / lake tapping. Live lake tapping method was implemented successfully in Koyna project to install additional hydroelectric units without emptying the Koyna reservoir.

Medium size WPP units can also be installed at irrigation canal drops to utilize the released water energy for pumping water in to a high level branch canal which would supply irrigation water to lands situated above the main water canal. Thus the water energy available is fully utilized for irrigation with optimum investment.

PUMPED STORAGE SCHEMES:

Sometimes it is not feasible to build a large storage reservoir on the main river itself. In this situation, the large storage reservoir is created on a small tributary of the river by envisaging Pumped Storage Scheme (PSS). PSS consists of a dam across the small tributary with reversible hydroelectric turbine units. During monsoon season, it pumps water from the down stream main river in to the upstream reservoir situated on the small tributary. Whenever water is required in the down stream river, the stored water in the reservoir is released in to the river after generating hydro electricity by the PSS. Nearly 75% of the pumping power consumed is recovered when water is released in to the river. During monsoon period, cheap secondary power is consumed for pumping operation and peaking power is produced during dry season by PSS. Since the peaking power is sold at premium rates than secondary power consumed, it becomes economical proposition from its electricity revenue itself. PSS not only consumes surplus secondary power and also produces peaking power. PSS can also be used as pumping station for lift irrigation. PSS creates storage reservoir for containing floodwater, which will go waste otherwise. Generally, non-overflow earth dam is envisaged in PSS since the reservoir storage capacity is many times greater than its basin inflows and the floodwater can be passed via its hydro turbines. PSS is a multipurpose project, which will meet all of the following requirements.

- To create storage reservoirs,
- To consume excess power in the electricity grid on daily as well as seasonal basis,
- To supply peaking power on daily as well as seasonal basis,
- To maintain optimum reservoir levels in down stream reservoirs to maximize irrigation and power benefits,
- To work as a pumping station for supplying water for lift irrigation, industrial, drinking water, etc. usage.

There are many possible sites available to locate PSS for creating storage reservoirs to meet the water and power requirements in AP on all major and medium rivers. While selecting PSS, the endeavor shall be to make them multi purpose for better usage. Some of the feasible PSS locations are given in Table-3 (refer Google earth web site for more details).

River	Tributary	Downstream reservoir	Geographical Location	FRL (mMSL)	Downstream level (mMSL)	Gross Storage (TMC)
Godavari	Godavari	Edira	18° 49' 59" N & 79° 52' 23" E	125	95	150
Godavari	minor	Edira canal with WPP	18° 02' 50" N & 80° 25' 48" E	260	120	100
Godavari	Lakanavaram	Edira canal with WPP	18° 08' 40" N & 80° 12' 17" E	260	140	60
Godavari	minor	Edira	18° 12' 41" N & 80° 41' 05" E	140	95	100
Krishna	Dindi	Nagarjuna Sagar	16° 22' 20" N & 79° 10' 01" E	250	140	150
Krishna	minor	Jurala left lift canal	16° 41' 25" N & 77° 45' 60" E	490	360	200
Krishna	minor	Srisailam	16° 04' 47" N & 78° 24' 21" E	330	240	150
Tungabhadra	minor	Rajolibanda	15° 54' 42" N & 77° 08' 21" E	350	334	50
Tungabhadra	minor	Tungabhadra	15° 13' 53" N & 76° 23' 31" E	600	470	20
Pennar	Cheyzeru	Somasila	14° 24' 18" N & 79° 11' 46" E	155	100	100
Vamsadhara	medium	Barrage	18° 43' 10" N & 84° 00' 13" E	55	40	30

Table-3: Some of feasible sites of PSS in AP

WATER USAGE:

The following irrigation canals are proposed from the Edira and Polavaram reservoirs (refer Figure-2).

Polavaram Dam:

1. To supply complete water requirements of Dowlaiswaram barrage. The energy contained in water released to Dowlaiswaram barrage from Polavaram dam would drive the envisaged WPP units.
2. Polavaram right bank gravity canal up to Krishna River with 40.32 m MSL canal sill level.
3. Polavaram left bank gravity canal up to Visakhapattanam with 40.32 m MSL canal sill level.
4. Polavaram right bank lift canal up to Pulichintala reservoir on Krishna River with 80 m MSL canal sill level with the help of WPP units.
5. Polavaram left bank lift canal with 80 m MSL canal sill level with the help of WPP units. This canal would supply water to up lands in East Godavari, Visakhapattanam and Srikakulam districts.

The substantial dead storage water below the gravity canals sill level can also be used to meet all the requirements with the help of WPP units.

Edira Dam:

1. To release the shortfall water for Polavaram dam requirements. The energy of water released from Edira dam would drive the envisaged WPP units.
2. Edira right bank gravity canal to irrigate lands up to Polavaram back waters with 75 m MSL canal sill level.
3. Edira left bank gravity canal to interlink with Talliperu reservoir with 75 m MSL canal sill level.
4. Edira right bank lift canal up to Nagarjunasagar tail pond on Krishna river via Kinnerasani reservoir at 120 m MSL canal sill level with the help of WPP units.

A branch of Edira right bank lift canal will also serve as water source for water transfer in to Ramappa lake (geographic location 17°57'08" North and 79°59'05" East) at FRL 255 m MSL by envisaging a PSS. Ramappa lake is located in Krishna basin. The water transferred from Godavari to Ramappa lake, will be used by gravity for irrigation up to Nagarjunasagar reservoir back waters bringing vast area under irrigation in Krishna basin areas falling in Khammam, Warangal, and Nalgonda districts. Construction of a PSS (geographic location 18°02'50" North & 80°25'48" East) on small tributary of Godavari will enable transfer of water by tunnel to Ramappa lake. This PSS would have nearly 100 TMC storage capacity. The dead storage water of the PSS is released in to the Edira right bank lift canal for irrigation use after generating electricity during dry season.

S.No.	75% dependable water requirement	Million m ³
1.	From Dowlaiswaram Barrage (FRL 15 m MSL):-	
2.	Delta water in Godavari basin	3590
3.	Kolleru & Yeleru basins	3951
4.	Proposed Samarlkot canal extension	234
5.	Domestic & Industrial uses	181
6.	Inflow below Polavaram dam (-)	833
7.	Water released from Polavaram dam (Water energy of 30 m head to drive WPP units) (s. nos. 2 to 5 minus 6)	7123
8.	From Polavaram dam (FRL 45.72 m MSL):-	
9.	Irrigation water in Godavari basin by gravity canals	870
10.	Transfer to Krishna river as per inter state agreement	2265
11.	Extra water transfer to Krishna river	2189
12.	Utilization in adjacent basins by gravity canals	2564
13.	Vizag city water supply	664
14.	Water to lift canals at sill level 80 m MSL with WPP (pumping head 35 m from 45 m MSL)	4411
15.	Polavaram reservoir evaporation loss	989
16.	Direct water consumption from Polavaram dam (s. nos. 9 to 15)	13952
17.	Total water requirement from Polavaram dam including water released to Dowlaiswaram Barrage (s. no. 7 + s. no. 16)	21075
18.	Dependable availability at Polavaram below Edira dam (refer Table-2)	10013
19.	Water usage from Edira dam (FRL 95 m MSL):-	
20.	Water to be released from Edira dam (Water energy of 45 m head to drive WPP units) to Polavaram dam(s. no. 17 - s. no. 18)	11062
21.	Right and left gravity canals usage	547
22.	Lift canal to link tail pond of Nagarjuna Sagar with sill level 120 m MSL with WPP (pumping head 25 m from 95 m MSL)	10065
23.	Lift canal to proposed PSS with sill level 120 m MSL with WPP (pumping head 25 m from 95 m MSL)	4000
24.	Direct water consumption from Edira dam (s. nos. 21 to 23)	14612
25.	Total water requirement from Edira including water released to Polavaram dam. (s. nos. 20 + 24)	25674
26.	Total Availability of water at Edira dam (refer Table-2)	25674

Table-4: Usage of Godavari Water from Edira and Polavaram irrigation projects

A PSS would be constructed with FRL 125 m MSL across Godavari River (geographic location 18°49'59" North and 79°52'23" East). This PSS is situated just upstream of

Pranhita confluence point. This PSS would have nearly 150 TMC gross storage capacity. Though this reservoir is located on Godavari main river, it does not have dependable water inflow. PSS would pump water in to this reservoir from the down stream river (95 m MSL). Thus this reservoir will also store Godavari river water and it is used to supply irrigation water in uplands by lift canal and low lands by gravity canal in Adilabad district.

With the above canals most of the area lying north of Krishna river will be irrigated by Godavari river water. There would be facility to pump Godavari water in to Nagarjunasagar reservoir with its reversible hydro turbine units. There would also be facility to pump Godavari water in to Srisailem reservoir with its reversible hydro turbine units from Nagarjunasagar reservoir in case of distress requirement. Thus Godavari water can be utilized in most of the existing and future irrigation projects in AP.

The water balance for the Edira & Polavaram dams are given in Table-4 and Figure-3. As shown in Figure-3, nearly 18,476 million m³ water out of 36,520 million m³ is harnessed with the help of WPP units without consuming any external power. Another 4000 million m³ from Pranhita will be utilized in Adilabad district by proposed PSS across Godavari. In addition to 75% dependable flows, substantial surplus water is also available as shown in Table-2 at 50% dependability, which can also be utilized for irrigation by creating storage capacity.

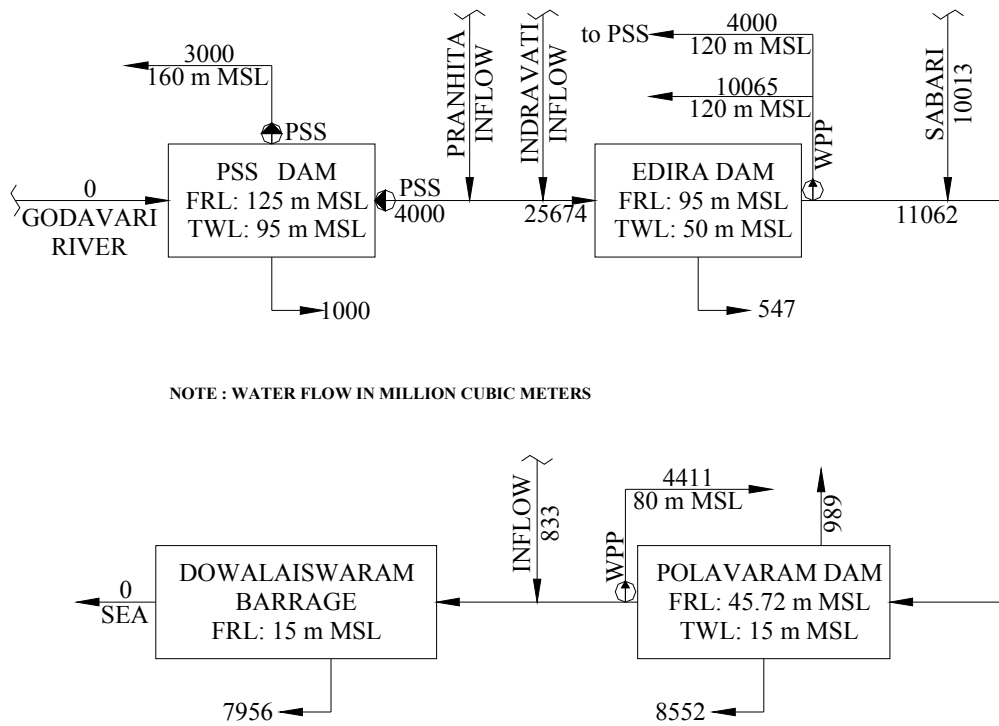


FIGURE-3: GODAVARI WATER UTILISATION FLOW CHART

The saved Krishna river water by the Godavari water diversion can be used from Jurala dam (FRL 316 m MSL) to irrigate uplands (up to 480 m MSL) of Mahboobnagar, Nalgonda, Rangareddy, Karimnagar and Nizamabad. This can be achieved by interlinking Jurala reservoir with Nizamsagar reservoir (FRL 428 m MSL) by envisaging

a PSS (geographic location 16° 41' 25" North & 77° 45' 60" East) in Mahboobnagar district. This canal will be passing very close to Hyderabad city to serve as one of its drinking water source. This canal also supplies water to some of the Sriram Sagar and Nizamsagar command area. Thus the saved water from Nizamsagar would be utilized for developing irrigation in Medak district from Singoor reservoir. The saved water from Sriram Sagar dam (FRL 333 m MSL) would be used to create irrigation facilities in uplands (up to 240 m MSL) of Adilabad district.

Another lift canal with PSS (FRL 360 m MSL) would take off from Jurala reservoir right bank and cover the uplands in Tungabhadra basin in Mahboobnagar district and join Tungabhadra river in the upstream of Rajolibanda barrage (FRL 334 m MSL) in Karnataka. A PSS would be envisaged in Kurnool district (geographic location 15°54'42" North and 77°08'21" East) with FRL 350 m MSL located on the small stream, which is draining in to the reservoir of Rajolibanda barrage. This PSS would store the flood waters (nearly 50 TMC) of Tungabhadra river for irrigation requirements in Kurnool district.

The saved water of Tungabhadra reservoir in Kurnool district can be utilized in uplands of Ananthpur and Cuddapah districts up to 450 m MSL by gravity canal. Also a PSS (geographic location 15°13'53" North and 76°23'31" East) with FRL 600 m MSL would be envisaged on Tungabhadra reservoir. This PSS would supply water available at Tungabhadra dam for upland irrigation up to 570 m MSL in Anantapur, Cuddapah and Chittoor of Rayalaseema region. This PSS project would be joint project of AP and Karnataka states since the existing Tungabhadra dam project located (geographic location 15°15'49" North and 76°19'59" East) in Karnataka, is a joint project of AP and Karnataka states. The availability of water could be further increased at Tungabhadra reservoir by interlinking it with Almatti reservoir or Narayanpur reservoir with the help of WPP units.

The dependable Krishna water would also meet the requirements from Srisailem reservoir fully. When water availability in Krishna river is below the 75% yield at Srisailem dam, water supply through gravity canals would get priority over the PSS fed canals in the upstream of Srisailem dam.

When above canals are crossing the coastal rivers and medium tributaries, either a balancing reservoir or a medium PSS could be envisaged to utilize the available water in the tributary / river. Thus all the coastal and tributary rivers water could be harnessed fully and efficiently.

LAND SUBMERGENCE:

Implementation of any big water storage project submerges vast area of land. If all the above projects were implemented, nearly 1% of AP area would get submerged. At the same time equal extent of water area would also be reclaimed by these projects. These are frequent flood prone areas of the rivers and the small water tanks / bodies in the command area. These small water tanks become redundant when assured canal water is available and ultimately converted in to fields by locals. When the storage reservoir is empty, most of the live storage area can also be used for summer crop by lift irrigation with ground water. During lean flow season, the riverbed is also used for cultivation when unexpected floods are prevented by upstream dams.

Many times, controversies erupt in allocating forest lands for construction of water reservoir projects/ dams. It is argued that precious forest lands are submerged by reservoirs. Forests and reservoirs can occupy same area and exist symbiotically. Vast areas of fresh water inundated forests exist in Amazon River basin of South America. The tree species in these forests can grow up to 20 meters height with 4 meters deep water logging for more than four months in a year. The climatic conditions of Amazon River basin are similar to Indian climate. It is possible to grow thick forests in the rim of existing water reservoirs / tanks up to four meters water depth. New reservoir projects could be created with out any loss of forest area by growing compensatory fresh water inundated forests in existing reservoirs / tanks. There are nearly 6500 square km of water spread area covered by man made reservoirs and water tanks in AP. Thus water bodies are put to multipurpose productive usage.

REHABILITATION & COMPENSATION:

These irrigation projects also displace large number of people whose lively hood is agriculture and forestry. These people are to be rehabilitated satisfactorily and compensated for loss of their livelihood and properties. Nearly 25% of agriculture land in the state is owned by absentee landlords who are mostly salaried class employees in government or private sector. Adequate land falling in the command area of a project could be identified and purchased at prevailing commercial rates from these absentee landlords for rehabilitating the effected population. Thus the irrigation facilities created at government cost are enjoyed by the effected population on first right basis.

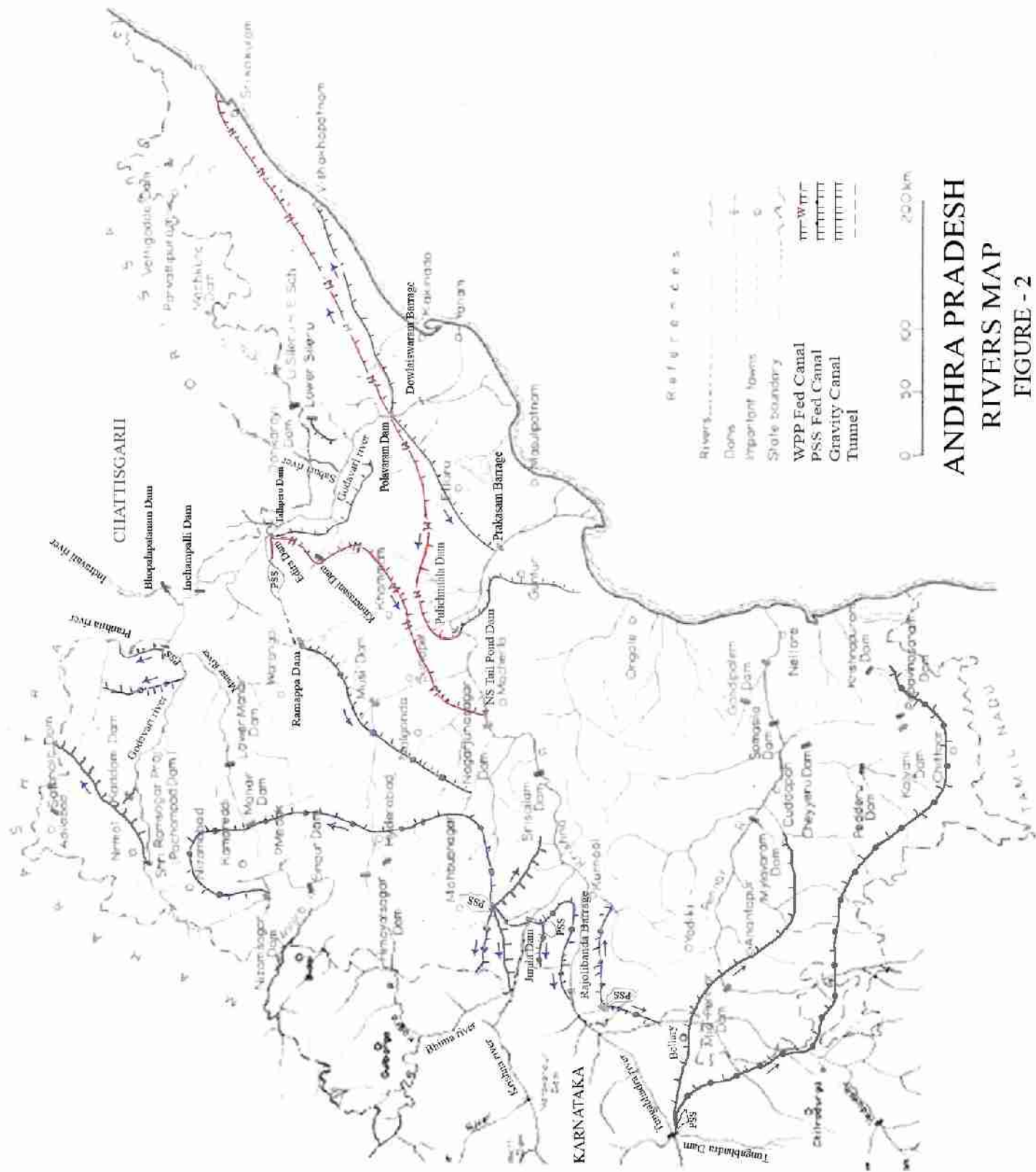
Presently, AP state is allocating nearly 50% costs of the irrigation projects for rehabilitation and compensation. The money spent on rehabilitation and compensation costs would not go waste as it will ultimately contribute to the state / local economy better than project construction cost. Project construction cost involves mainly expenditure towards imported machinery and diesel oil purchases whereas compensation & rehabilitation money spent is available to local economy fully. The effected population would not oppose the construction of water storage projects if credible and attractive compensation package is offered.

REORGANIZATION OF STATE OWNED POWER COMPANIES:

Presently AP Genco is managing the assets of power projects including hydropower projects. Hydro projects generate seasonal power during monsoon period and peaking power during rest of the year. AP Discoms distribute electricity to the agriculture pump sets during off peak hours. Enactment of Electricity Act 2003 has paved the way for selling and purchasing electricity on demand & availability basis. If the hydropower project assets managed by AP Genco and agriculture pump set's power distribution system assets managed by AP Discoms are separated and brought under a new government company, it would make good economic synergy to supply free power to farmers and eliminate the agriculture power subsidies. The off peak power for agriculture consumption would be purchased cheaply whereas the peaking power generated would be sold at highest price.

The proposed company would be profitable venture after supplying free power for agriculture. One unit (kwh) of peaking power generated by PSS and hydroelectric stations would be exchanged for 2.5 to 3 units of off peak power supplied to agriculture. The secondary power generated by hydroelectric stations and the cheaply available

surplus grid power during monsoon season would be used as pumping power needed by various PSS. The total pumping power required by various lift irrigation PSS projects will not exceed 8.0 billion units in a year as shown in Table-5. The off peak power availability goes on increasing as the industrial and domestic electricity demand increases due to industrialization. The electricity demand by agriculture & PSS would perfectly fill the gap by consuming the surplus off peak power. Creation of dedicated power company for agriculture purpose would also generate sense of belongingness in the entire state population that these water storage projects are not only creating irrigation facilities by canals in a particular area and also providing free power for irrigation requirements located in distant uplands through out the state.



**ANDHRA PRADESH
RIVERS MAP
FIGURE - 2**

TABLE-5: WATER USAGE FROM KRISHNA AND GODAVARI RIVERS

Project Name	75 % dependable water allocation from Krishna river (TMC)		Requirement at upstream of Srisaillam dam (TMC)	From Godavari river (TMC)	50% dependable water allocation from Krishna river (TMC)	Pumping Head (Meters)	Pumping capacity (MW)	Requirement in 100 years. (%)	Average pumping power consumption (Million Units)	Remarks
	Existing	Proposed								
Krishna Delta	180.2	20		160.2			-			
Nagarjuna Sagar (NS) canals	281	14.05		155.95	69.85	75 85	499 253 (-)	85/50 50	747 273 (-)	Existing PSS
Assistance to NS left bank canal from Edira WPP canal				34			-		-	
NS tail pond right canal				77			-		-	
Srisaillam evaporation	33	0		-						
Jurala	17.84	17.84	17.84				-			
KC canal	39.9	39.9	39.9							
TB LLC	29.5	29.5	29.5	-		40	50	100	109	New PSS
TB HLC	32.5	32.5	32.5	-			-		-	
Rajolibanda	15.9	15.9	15.9				-		-	
Medium & minor	170.16	170.16	39.18	-			-		-	

TABLE-5 Contd

Project Name	75 % dependable water allocation from Krishna river (TMC)		Requirement at upstream of Srisaillam dam (TMC)	From Godavari river (TMC)	50% dependable water allocation from Krishna river (TMC)	Pumping Head (Meters)	Pumping capacity (MW)	Requirement in 100 years. (%)	Average pumping power consumption (Million Units)	Remarks
	Existing	Proposed								
Chennai water supply by Karnataka & MR	10	0	0	15	15	75 85	48 54 (-)	50 50	52 59 (-)	Existing PSS
Additional share by Karnataka & MR	-35	-								Polavaram share
Velugodu		40	40							
Hindri Neeva		10	10							20 shifted
Galeru-Nagari		10	10							20 shifted
Telugu Ganga		10	10	17.6	17.60	75 85	56 64 (-)	0.5 0.5	61 69 (-)	Existing PSS
SLBC		30	30							
TB LLC (Stage II)		20	20							
Jurala LB (lift) with PSS		145.25	145.25		19.58	180	1265	100 50	2408 162	New PSS
Jurala RB (lift)		20	20			40	34	100	74	New PSS

TABLE-5 Contd

Project Name	75 % dependable water allocation from Krishna river (TMC)		Requirement at upstream of Srisaillam dam (TMC)	From Godavari river (TMC)	50% dependable water allocation from Krishna river (TMC)	Pumping Head (Meters)	Pumping capacity (MW)	Requirement in 100 years. (%)	Average pumping power consumption (Million Units)	Remarks
	Existing	Proposed								
TB HLC -II		47	47			-	-			Almatti to Pennar link
TB Dam PSS		144.03	144.03		21.97	130	920	100 50	1724 131	New PSS
Total availability	775									at 2060 TMC
Possible allotment	825.87	816.13 (-9.74)	650.93		144			at 2191 TMC 75% availability at 2562 TMC 50% availability		
S RBC	19	19								Regeneration flows
NS RBC (Stage II)				50		75	160	85	294	
Pulichintala RBC				50		-				
Between Godavari & Krishna from Edira by WPP canal				27.45						
Between Godavari & Krishna from Edira by PSS				109.7		140	655	100	1414	New PSS

TABLE-5 Contd

Project Name	75 % dependable water allocation from Krishna river (TMC)		Requirement at upstream of Srisaïlam dam (TMC)	From Godavari river (TMC)	50% dependable water allocation from Krishna river (TMC)	Pumping Head (Meters)	Pumping capacity (MW)	Requirement in 100 years. (%)	Average pumping power consumption (Million Units)	Remarks
	Existing	Proposed								
Polavaram gravity & WPP canals				247.39		-	-			
Dowlaiswaram Barrage				280.84		-	-			
Adilabad Dt. PSS				141.2		60	361	100	780	New PSS
Edira gravity canal				19.31		-	-			
Total				1395.44			3445		7555	3445 MW new PSS

Notes:

- (-) The 50% dependable water is used for power generation in Srisaïlam hydropower station before using for irrigation from Nagarjuna Sagar reservoir.
- The possible water allotment to AP is calculated as per Scheme B proposed in Bachawat Award for sharing excess / deficit water in proportion to 2060 TMC availability.
- NWDA has projected 2191 TMC (131 TMC more) availability at 75% dependability and 2562 TMC availability at 50% dependability in Krishna river.
- The water requirement of Karnataka and Maharashtra states are projected as 866.44 and 508.43 (excluding 112.43 TMC westward diversion for power generation) respectively. This is to achieve irrigation facilities for one third of cultivable area in Krishna basin area of Karnataka and Maharashtra states.
- The regenerated water available from irrigation use is approximately equal to evaporation in reservoirs and net surface water usage for domestic & industries.

Table-6: Water availability and requirements in Andhra Pradesh

Basins	River basin approximate area (Sq. Km)	Culturable area		Water requirement (million m ³) for 60% of culturable area irrigation.		
		(Hectares)	% of basin area	In basin useful water availability	Import	Total
Medium & Minor rivers north of Godavari	30534	1716011	56.20	5134	3103	8237
Godavari river	74449	4039000	54.25	49497	(28110)	21387
Medium & Minor rivers between Godavari & Krishna	11500	760000	66.09	700	2948	3648
Krishna river	76131	5257000	69.09	23120	2114	25234
Medium & Minor rivers between Krishna & Pennar	21057	1623000	77.08	1500	6290	7790
Pennar river	48587	3028000	62.32	3934	10600	14534
Medium & Minor rivers south of Pennar river	12810	777000	60.65	1100	2630	3730
Water supply to Chennai	-	-	-	-	425	425
Total	275068	17200011	62.53	84985		84985
() export to other basins				Irrigation water requirement is 8000 m ³ per hectare		

The agriculture pump sets power consumption in the year 2004 is 13.45 billion units, which is 35% of total electricity consumption in the state. The entire rainfall (75 cm average) in the state can be pumped at 60% pumping efficiency from a depth of 14 meters with the pumping power consumed in agriculture. Most of the agriculture pump sets in the state are installed at ground level with foot valve (not submersible type) whose pumping heads are less than ten (10) meters. There is vast scope for energy and water conservation. This company would also strive to educate the farmers about energy efficient pump sets to enhance its profitability and growth.

ROLE OF CENTRAL PUBLIC SECTOR AND PRIVATE SECTOR:

Presently, National Hydro Power Corporation (NHPC) and National Thermal Power Corporation (NTPC) are executing hydropower projects in Himalayan regions. Till now, these central public sector companies have not taken up any hydro project located on peninsular rivers though there are many attractive feasible projects. NHPC or NTPC shall take up Bhopalapatnam hydroelectric project and supply the generated power to Chattisgarh and Maharashtra states on first preference basis. This would help AP in harnessing Godavari water for irrigation purpose. Also PSS units shall be commercially packaged and offered to private sector for implementation. This would bring in private sector investment also to harness the available river water at a faster pace.

CONCLUSION:

The total irrigation water requirement and its availability in AP are shown in Table-6. By harnessing the Godavari water fully as explained above and creation of additional PSS storage reservoirs, nearly 90% area of AP would achieve full irrigation benefits. The energy of available Godavari water is also put to use efficiently and fully for uplands irrigation with the help of WPP units. The water used in irrigation would also recharge the ground water. These areas can get water for three crops in a year with the help of ground water. Aqua culture farms can also be developed on large scale to maximize value of production from the available water. It is not only availability of water but also availability of water head / energy which will make lift irrigation projects more economical. The endeavor shall be to maximize the available water head by optimum selection of FRL and tail water level of WPP units.

The inexhaustible surface resources such as arable land, sunlight, tropical climate and rainwater are harnessed by creating permanent infrastructure as explained above. This infrastructure will serve to achieve the ultimate stage of green and blue revolution in the entire state.

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The author (N. Sasidhar.) is a thermal power plant engineer with nearly 26 years experience.

Dedication: This paper is dedicated to Google earth web site for making available earth geographical data as free access software.