160 years of Irrigation and Drainage - The Saga of GDS & KDS

Dr. Rama Raju

1.0 Abstract

During the middle period of 19th century, the then British Government was in a spree of consolidating its hold on the Indian Sub-continent by wrestling power from Mughals and also from adjoining smaller provinces. A key challenge faced during the annexation campaign was severe famine during the years 1831-33, in which it is said that a third of the population has perished in Krishna and Godavari Delta regions. In as much as the avocation of majority of the population is farming, the then Govt has decided to construct Anicuts (1839-53) across Krishna River at Vijayawada and one more across Godavari River at Dowlaismwaram (v), Rajahmundry District. The total commanded area is about 8,75,000 Ha. The construction of these Anicuts is attributed as the noblest Engineering feat under the British Rule. Though the initial ayacut was much less, the increasing demand for Irrigation led to expansion of the same over the years.

To reduce the cost of construction and get the approval for the schemes from the ‘Court of Directors’ of East India Company, majority of the then existing drainage systems were converted into drain- cum-irrigation channels. Expansion of Irrigation during Kharif followed by the steady expansion of Rabi has created heavy pressure on the drainage system. Over a period of one century lot of improvement and extensions took place to the system to meet the increasing operational requirements. Govt of AP has taken up APCERP program with WB assistance to improve the drainage system in both GDS&KDS. The impact studies of the program revealed that the drainage improvement program has given the much needed drainage relief in both of these delta irrigation systems.

Generally, development in any river basin begins in the delta regions and moves to the interior parts in any river valley. As the River basins come to a closure, misery also begins in the delta region due to diminished and delayed river flows. The situation is worse during deficit years. In the last two decades both of these Irrigation systems are suffering due to diminished flows leading to curtailment of command. The situation is worse in Krishna Delta. However, all the stake holders like WUAs, Govt depts, have accepted the emerging challenges and adapted to using the meager flows efficiently by resorting to turn system, conjunctive use, applying water only as per the just crop water requirements etc. This has led to dramatic improvements in Water Use Efficiencies during the times of crisis.

In the recent years, aqua-culture has picked up in the two Deltas. This has turned as a boon for some tail end farmers but the eco-system is suffering with increased levels of pollution, salinity and water logging. The small farmers are getting suffocated under the pressure of new aqua entrepreneurs.

Consequent to the Re-organisation of the State of AP in 2014, the two delta regions have fallen in the territory of residuary state of AP. The re-organisation has brought about fresh physical and institutional challenges.
2.0 Krishna and Godavari are two large River systems in the Peninsular India

Krishna River originates in the Western Ghats region at Mahabaleswar in the state of Maharashtra and traverses through the states Karnataka Telengana and joins the sea in Andhra Pradesh. The Krishna river has formed a Delta in the penultimate stage before joining the sea. The catchment Area of the river is 2,58,948 sq.km and Krishna, Bhima, Tungabhadra are the main tributaries. The Bachwat tribunal (KWDT1) has determined the yield (75%) of the river as 58.33 TMCUM and earmarked 5.12 TMCUM for for KDS

Godavari River also originates in the Western Ghats near Nasik in Maharashtra state and traverses across the states of Chattisgarh, Telengana, Orissa and joins sea in AP. Catchment area of Godavari River is 3,14,835 sq.km. The Godavari River also has formed a Delta before joining the sea.

2.1 Construction of Head Works, the noblest engineering feat of British India

Towards the end of first half of previous century, the life in the two Delta regions had fallen into a sad case. The abolition of the East India Company’s factories (related to cloth trade) due to competition from Manchester &European looms has drastically diminished the socio-economic conditions of the region. In 1832-33 a terrible famine has ravaged the area followed by three unfavorable years, 1835-36, 1836-37, 1837-38 followed by the calamities of 1838-39,1839-40 and almost equally calamitous season of 1840-41. It is known as ‘Dokkala Karuvu’ (only ribs are seen without any flesh). It is said that a third of the population has perished during the same period. Later, while describing the above acute condition’s Lady Hope (daughter of General Sir Arthur Cotton) writes that children were sold for ‘Two Annas’ like other commodities in the farmers markets to survive.

The then Govt has responded to the above calamitous situation and deployed it’s ablest Administrators (Mr.Montgomery) and Engineers (Sir Arthur Cotton) and provided the necessary Administrative sanctions for construction GDS&KDS. The sanctions included major items like Anicuts across the rivers, Irrigation canals, Aqueducts, channels&sluices, flood banks, river training works, Roads and bridges etc.Krishna Delta.

2.2 Construction of Prakasam Barrage

Prakasam Barrage was constructed to replace functions of the old anicut during the period 1954-57. It consists of 70 spillway gates of size 40'X12' each with eight of scour vents of 17'X12' size on Seethanagaram side and six scour vents of 17'X12' on Vijayawada side of the barrage. The crest level of the regulator is 45.05 ft and the sill level of the scour vents are 36.30 ft. The regulator was constructed by combining it with a road bridge on upstream side of the anicut, duly availing the presence of the anicut with a view to reduce the cost.
2.3 Construction of Sir Arthur Cotton Barrage

The old anicuts consisted of anicuts in four arms of river Godavari near Dowlaiswaram with a crest level of +36.00 ft. and the irrigation potential originally envisaged in the year 1852 was 6.12 lakh acres. During 1862 to 1867, the crest of the anicut was raised to +38.00 ft. but the ayacut brought under cultivation by then was 4.36 lakh acres only. 2.00 ft. falling shutters were installed raising the crest level to +38.75 ft. in 1898 increasing the Ayacut to 6.40 lakh acres. Even this level was found inadequate to meet the rapid expansion of irrigation and during 1936 the Ayacut increased to 9.81 lakh acres with introduction of 3.00 ft. falling shutters.

Due to the increased water level on the anicut and ageing, the soundness of the structures deteriorated. Extensive damages took place to the left end of Ralli anicut during the floods of 1963. The Geophysical investigations revealed that the anicuts are in a precarious condition due to undermining of foundations. Due to dilapidated condition of the old anicut, SAC Barrage was constructed during 1970 –1984.

The pond level of Barrage is +13.64 M. The Godavari Barrage Project includes construction of new head sluices for all the three main canals with silt elimination measures in canals.

Salient features of Godavari Barrage (Sir Arthur Cotton Barrage):

<table>
<thead>
<tr>
<th>S.No</th>
<th>Name of arm</th>
<th>Length</th>
<th>No of vents</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Dowlaiswaram</td>
<td>1437.92 m</td>
<td>70</td>
</tr>
<tr>
<td>2</td>
<td>Ralli</td>
<td>884.45 m</td>
<td>43</td>
</tr>
<tr>
<td>3</td>
<td>Madduru</td>
<td>469.66 m</td>
<td>23</td>
</tr>
<tr>
<td>4</td>
<td>Vijjeswaram</td>
<td>800.64 m</td>
<td>39</td>
</tr>
<tr>
<td></td>
<td>Total:</td>
<td>3592.67 m</td>
<td>175</td>
</tr>
</tbody>
</table>
2.4 Emerging supply side Issues related to the Head works

In any river system, development begins in the penultimate reaches of the river basin and extends into the interior valley. Krishna Delta is not getting adequate flows even during Kharif due to construction of big storage Projects in the upper reaches of the river. The situation would be still worse if the KWDT2 allocations are utilised in the upper reaches of the river. The Tribunal also proposed for constitution of KWDIB(Krishna Water Decision Implantation Board.

The re-carved State of AP is proposing to draw water from Krishna River for its new Capital City.

The above diagram depicts availability of water per Hectare in the recently carved states of Telengana and AP. The inequity among the regions of the state of AP has worsened after the division of states. These two Irrigation systems will play a pivotal role to bring water security for other deficient regions of the state with large scale diversions in future.

The supply side changes for GDS have also become significant in the recent years, especially affecting summer flows at Sir arthur Cotton Barrage. Due to the inability to construct any new storages in the upper reaches of Godavary by any of the upper riparian state, the competition to tap base flows of the river has become severe.
The state of AP is constructing Polavaram Project above the SAC barrage (head works of GDS). Among other things, the following two provisions are significant with reference to GDS & KDS

1. 6.353 BCUM has been considered as the requirement of GDS
2. 2.265 BCUM as diversion to KDS

The Governments have to realise the strategic importance of GDS, KDS in the new geographical dispensation and expeditiously complete Polavaram Project to attain the overall water security of the state.

3.0 Canal Water Regulation

The broad principles followed for water regulation were modified from time to time. The following are the general principles.

1. During Kharif entire ayacut is served with Irrigation depending on the availability of water.

2. Each major canal is having about five lock cum regulating structures. The number of such regulators and spacing of such structures is canal specific, based on topography and the service requirements. The FSLs of the canal is governed by commandability and navigation depth as well. Navigation started declining in the past five decades and has become almost non-existent today. Currently the driving head for drawal of water into various off takes in the respective reaches is the guiding principle for the level to be maintained.

3. Inasmuch as the terrain is very flat (slope varies from 1:5000 to 1:15,000) and water table is shallow, paddy is the preferred crop followed by pulses and fodder crops. The drawal of quantities at head regulator is dependent on the stage of the crop.

4. Since transplantation period consumes a fourth of the total quantity of water, farmers are encouraged to complete it early to

   a. Attain sufficient height for the canopy of the crop, to sustain inundation during cyclone periods during NE monsoon (Oct-Nov).
   b. Take advantage of availability better supplies during the active period of monsoon.
   c. Get at least two months canal closure period for executing O&M works for canals and drains

5. In respect of GDS, the lands were categorised as Permanent zone, rotational zone (triennial, biennial), excluded zones as a basis to decide the extents. Notwithstanding the rotational system followed earlier, the Rabi extents in each year is decided based on anticipated summer flows. The anticipated summer flows are forecast based antecedent monsoon flows together with the proposed releases from Hydro-electric units located in the upper reaches of the river.
6. The Executive Engineer or any designated officer performs the following functions:

   a. Regulate and distribute water at canal head and at designated points
   b. Distribute without any preference
   c. If need be, adopt turn system to the canal or to its specified reaches
   d. Close canals for repairs or for any emergency
   e. Ensure that the registered ayacut is served
   f. Change lands across schedules and obtain Govt sanctions for such changes, if need be.
   g. Prevent unauthorised insertion pipes
   h. Provide water for drinking water tanks as per agreed schedules.
   i. Prepare and submit daily water reports of various reaches of canals, locks escapes
   j. Irrigation Registers: Division Office shall check the caculations and enter it into registers.
   k. Water statistics: at the end of the season, Reachwise water used per unit of land (acre)

3.1 Problems encountered in water regulation

The physical condition and its appropriate operation of water regulating structures is the key to a successful water regulation. The following difficulties are experienced by the field staff.

1. The Prakasam Barrage and SAC Barrage are life line for these vast Irrigation systems. The Dam safety organisation has pointed out deficiencies in respect of Civil works and Mechanical works. These items require special attention keeping the interests of the farming community spread in four districts in particular and overall water security of the state. Non- availability of emergency gates for Prakasam Barrage is a major challenge. Inadequate energy dissipation in this barrage is causung damage to the aprons and CC blocks.

2. The total service area has expanded to 8,75,000 Ha. The canals and distributories have become old and need improvement. The capacities of the canals have become inadequate due to siltation. This is causing delay in supplies, especially during transplantation period thereby exposing crops to fervour of cyclones. Canals require lining in sandy reaches.

3. All the regulating structures have outlived their life and showing severe signs of distress and need replacement by fresh construction.

4. The flood disposal capacities of Cross drainagae structures is inadequate in respect of specific structure. Such structures require additional vents.

5. The outlet capacities are inadequate in respect inlet/outlet cross drainage works.

6. Considerable wastage of water is taking place as regulating arrangements for sluices are in damaged condition.

7. Essential requirement for Canal Water regulation is voice and data communication for taking appropriate and timely decissions, and dissemination of such decissions. ITD(now BSNL) has supported single wired canal communication system for more than one century. Such services were discontinued due to obsolescence of technology. There is urgent need to restore data and voice communication for better water regulation.
4.0 River conservancy

Rivers carve-out their own unique morphological features. Such features are further unique in the penultimate reaches of the river before its confluence with sea. As the sea level controls behaviour in this reach, the degree of turbulence comes down and the river drops the silt it was carrying hitherto. Due to such deposits, the rivers develop a tendency of running on a ridge during flood period in the delta regions. In as much as the river runs on the ridge, elaborate protections works with flood banks are required to arrest spills. The river course needs to be trained with training works like groynes and spurs to remain in its course. Such need was recognised while constructing the Anicuts itself, and provision was made for such works in the Cost estimates(1847).

4.1 River Conservancy Act:

As the Governmental machinery has to act swiftly and decisively during the emergency times of flood, it empowered itself with a Madras River Conservancy Act(1882) for various functions like appointing Conservators, Enter upon private lands, define river bed, conduct surveys, alter river limits, prohibit cultivation, prohibit construction, lay penalties, make Acts etc. Under the above empowerment, the WR Dept has constructed the following flood banks.

<table>
<thead>
<tr>
<th>River</th>
<th>Number and length of Banks</th>
<th>Design flood*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Godavari</td>
<td>13 flood Banks, 535 km</td>
<td>1953 flood of 28,00,000 cusecs*</td>
</tr>
<tr>
<td>Krishna</td>
<td>13 flood Banks, 346.40km</td>
<td>1908 flood of 10,60,830 cusecs*</td>
</tr>
</tbody>
</table>

* Certain specified reaches have higher design standards
**Both the rivers have received much higher floods during the subsequent period, Krishna :11,90,000 cusecs(2009), Godavari:35,00,000(15-8-1986)

4.2 Annual Contingency Plan of Action

As a sequel to the above Act, the WR dept prepares an elaborate Contingency plan and flood patrol rules every year. The plan comprises of description of the infrastructure(flood banks, set works, vulnerable reaches,flood stores etc), warnings, messages, forecast mechanisms, travel time for floods, reachwise flood duty officers, duties to be performed etc. The flood duty officers are drawn from all Govt Departments. Each flood duty officer is expected to go through the the said plan and familiarise with his jurisdiction well in advance before floods and perform his duties in a structured manner.
The map shown above indicates the elaborate infrastructure for River Conservancy.

The following improvements are required for the above arrangements.

1. The flood banks are to be improved to the revised standards like design flood, top width, standard slopes, berms, river margins etc.
2. Take up river training works like set works, groynes, spurs and pitching and revetment are inadequate.
3. The out-fall sluices have outlived their life and need replacement.
4. Every season, the flood stores need to be replenished with flood materials as per standards.
5. The safety and stability of flood banks is under threat from Aqua culture.
6. The water way of the river is getting restricted by Aqua culture and also due to cultivation in margin lands.
5.0 Inland Water Transport

There are a number of rivers in Andhra Pradesh. Of these the important ones are the Godavari and Krishna. In addition to these rivers, there is a network of canals in the Krishna – Godavari Delta and the Buckingham Canal.

The following Canals have been considered for the Inland Water Transport by the Government of India.

**Canals**

1. Kakinada Canal (Kakinada – Rajahmundry) . . 50 Km.
2. Eluru Canal (Rajahmundry – Vijayawada via Eluru) 139 Km.
3. Commamuru Canal (Vijayawada–Pedaganjam) . . 113 Km.
4. Buckingham Canal (Pedaganjam– Mercaunam) 443 Km.

**Rivers**

1. River Krishna (Wazirabad – Vijayawada) . . 157 Km.
2. River Godavari (Bhadrachalam – Rajahmundry) 171 Km.

**Total** 1073 Km

Present corridor width in canal system is lying from 15 M to 40 M and Depth 3.5 M to 1.5 M. The required corridor width and depth for Navigation purpose are 50 M and 1.8 M respectively. Additional width required for increasing cargo-road facility on top of Bank will be about 25 M.

6.0 Drainage System

The storms and depressions that develop in Bay of Bengal during monsoon season move across the coastal areas of Andhra Pradesh, causing heavy to very heavy rains. Andhra Pradesh has 1050 Km length of coastal line. This coast line, being the most cyclone prone zone in India was hit by about 90 cyclones since 1900 AD. According to one study, tropical storms originating from Bay of Bengal strike the densely populated parts of the Coast causing serious floods, causing misery to the inhabitants of the area, besides loss of life and loss to public and private properties.

The storms and depressions on the East Coast of India are very frequent and severe in nature. They vary in size from 60 Km to 240 Km in diameter and have different intensities and core wind velocities some times reaching upto 325 Kmph. Nearly, 50 % of the storms on East Coast occur along the Andhra Coast causing very severe storm tides in the Krishna and Godavari Deltas.

6.1 Drainage Problems

The irrigated area in Krishna and Godavari Deltas is served by a number of major, medium and minor drains for disposal of the surplus water from fields, that accumulated especially during the monsoon, when the area is subjected to incidence of heavy rain & wide spread rainfall. Rapid disposal of surplus water is the prime purpose for which the drains are intended to serve. The objective is not effectively achieved, owing to congestion of drains due to several reasons. The problem of “drainage congestion” in delta occurs generally between the
elevation (+) 10.00 m and the sea level. It is more acute, since the terrain is very flat in vast extent of tracts. The following table gives an overview of the arrangement.

<table>
<thead>
<tr>
<th>Delta</th>
<th>Extent of Ayacut in Ha.</th>
<th>Drainage Net Work</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Major Drains</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nos.</td>
</tr>
<tr>
<td>G.E. Delta and G.C. Delta</td>
<td>2.104</td>
<td>19</td>
</tr>
<tr>
<td>G.W. Delta</td>
<td>1.983</td>
<td>22</td>
</tr>
<tr>
<td>K.E.Delta and K.C. Delta</td>
<td>2.986</td>
<td>16</td>
</tr>
<tr>
<td>K.W. Delta</td>
<td>2.02</td>
<td>27</td>
</tr>
<tr>
<td>-do-</td>
<td>0.29</td>
<td>19</td>
</tr>
<tr>
<td>Total</td>
<td>9.383</td>
<td>103</td>
</tr>
</tbody>
</table>

6.1 Causes of drainage congestion

1. Increase in the irrigated areas in the upland catchments, as in the case of Nagarjuna Sagar Right Canal Command and lack of commensurate improvements to Drainage network.
2. Increase of irrigated area in deltas without commensurate improvements to drainage network.
3. Cultivation of flood plains depriving the natural facility of flood moderation.
4. Use of some drains as irrigation channels.
5. Formation of roads without a proper appreciation of the consequent drainage problems.
6. Inadequate water way in cross drainage and cross masonry works.
7. Simultaneous floods in rivers and drain joining them.
8. Heavy rainfall in three consecutive days exceeding 387.50mm which is the norm to compute the MFD in designing drains.
9. Obstruction to flow of drain due to formation of sand bars at their confluence with the Sea.
10. Obstructions caused by heavy embankment and roadways.
11. Max flood level of the drainage channel at or below the sea high tide level.
6.2 Chronology of important events in drainage improvement in GDS & KDS

1. Drainage was not that serious a problem, as the original extents of Irrigated area was much less, and the intensity of Irrigation was much less than 100%. Over the years, the extents of Irrigation have increased, and the intensity also reached to a level of 200%. To bring down the cost of the original scheme some of the existing drains were converted into Irrigation cum drainage channels.(1847-53)

2. First known major drainage scheme is said to be improvements to Pedalanka -1929

3. De-mobilised Army from WW-2 was engaged for improvement to Nallamada straight cut.

4. Drainage cess Act 1955

5. A.C.Mitra committee report 1964

6. Drainage cess Act 1968

7. Drainage cess Act 1985

8. Report Dr Sriramakrishnaih 1986


11. Economic Restructuring Project(APERP)


The above programs resulted in overall improvement of the vast drainage net work in the two deltas. The large scale improvements done under APCERP program has considered a 3-day average rainfall in a range of 387.5mm to 500mm. However the Cyclone OGANI (2006) has brought much higher 3-day precipitation in KDS area (ex: Pamarru-826mm,Gudivada-695.2mm, Gudlavalleru-680mm). The corresponding “C” value to be adopted for Ryve’s formula is computed as “156” against “115” adopted in CERP program. Thus it indicates that much desires to be done for the overall drainage system.

7.0 The boon and the bane of Aqua Culture

Tail end deprivation is common to all the Irrigation systems. The additional suffering to the tail end farmers in these two systems is water logging, salinity and exposure to cyclones. To mitigate such suffering the farmers in the fringes of the two deltas have started converting the irrigated lands into fish ponds from the year 1978. What has started as a fresh water culture has turned into intensive brackish water aqua culture leading to the following deleterious consequences.

1. All the drains carry high levels of saline water, organic contents, and nutrients. Such highly concentrated loads have upset the eco-system.

2. Some of the drains are, drain cum irrigation channels. Such channels are the only source for filling drinking water to the notified drinking water tanks. Due to the presence of high organic load and nutrients in such supplies is leading to Algal blooms in the drinking water tanks and rendering such waters unfit for human consumption.
3. Storing water of water at higher than specified levels is leading to water logging in the neighboring fields.
4. The small farmers are getting suffocated and uprooted under the pressure of new aqua entrepreneurs.
5. The banks of the canals and drains are getting damaged due to seepage from the aquaculture tanks.
6. Impending threat of climate change would further damage the system due the increased groundwater levels with salinity.

There is urgent need to bring in a strong regulatory mechanism to mitigate the above cited consequences.

8.0 Conclusions

KDS and GDS are the two great assets we have inherited from our glorious past. It is the responsibility of the present generation to sustain and protect these capital assets and pass it on to the next. The system is facing several natural and manmade threats. It is the bounden duty of all stake holders including Administrators, Engineers, farmers, general public to ensure that these great systems are on a sustainable track and keep enriching the future generations. These two Irrigation systems contribute about 15 Million tons of food grains for the food security of our country apart from several secondary agro-related benefits. The Union Govt as well as state Govts should give top priority for sustaining these highly productive systems.

9.0 References

1. The Engineering Works of Godavari Delta- George T Walch, Chief Engineer, Madras
5. Biography of ‘General Sir Arthur Cotton’ written by his daughter Lady Hope.
6. Irrigation localisation GO of 1944
7. Madras River Conservancy Act
8. Annual Contingency Plan prepared by the River Conservator, East Godavari Dt
9. Inputs and suggestions from the Chief Engineers of GDS&KDS, their able field officers, my colleagues from CBIT