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IWRM studies in Errakalva River Basin: Hydrological management practice plans in Y-Drain system

National Institute of Hydrology

Deltaic Regional Centre

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Preface

Water has always been a scarce resource in any River basin at certain period of an year. Most of the precipitation falls during monsoon season and it is highly variable year-to-year, but the long warm summers are always dry. In the middle of 20th century, responsible agencies built a system of reservoirs, canals, pumps and pipelines to store water and deliver it to agricultural and urban users in dry areas. In the name of development schemes each Institution is taking up programmes and projects to suit its primary objective and overlooking the detrimental effects that may even harm its primary objective in long term.

There is need to cope up with stresses on a given river basin. This is because basin water resources are committed and there are challenges posed by water quality and its scarcity. Societies respond to water shortage at basin scale and local scale in many ways, at both the individual and community level and the different basin regions. While the main emphasis is on the coping strategies of the state and technical expertise, the responses at different levels of society are often not included.

This study on 'Hydrological management practice plans in Y-Drain system' is part of IWRM studies in Errakalva River Basin of the Institute and is part of work programme of the Deltaic Regional Centre, Kakinada. The study was carried out under the supervision of Dr. J. V. Tyagi, Scientist G and Coordinator by Dr. S. V. Vijaya Kumar, Scientist F as Principal Investigator. Dr. Y. R. S. Rao, Scientist F, Dr. V. S. Jeyakanthan, Scientist E, Dr. J. V. Tyagi, Scientist G as other investigators with Shri U. V. N. Rao, P.R.A and P. R. Rao, R.A., as support staff.

Abstract

P In the name of development schemes each Institution is taking up programmes and projects to suit its primary objective and overlooking the detrimental effects that may even harm its primary objective in long term. There is need to cope up with stresses on a given river basin. This is because basin water resources are committed and there are challenges posed by water quality and its scarcity. Societies respond to water shortage at basin scale and local scale in many ways, at both the individual and community level and the different basin regions.

Due to u/s diversions at Duvva regulator, the contribution from irrigation return flows and base flows has significant effect on quality of stream flows down stream. Further down stream with the confluence of Gosthanadi with Y Drain though there is increase in river flow its quality is dominated by the effluents from Gosthanadi apart from that of irrigation retuen flows and base flows. It is observed that due to unilateral way of providing irrigation for 2 to 3 crops in the with the study area which is part of Godavari delta command area system, there is interference with natural flows in Yerrakalva river and on its drainage, that has gone unnoticed. The water resources department itself is the custodian as conservator of the stream and only should be aware of the importance of allowing sufficient discharges to maintain river eco system.

Hence, assuring a secure water future is becoming more costly and increasingly uncertain. To effectively develop and manage water resources from local to national level, there is necessity for stronger collaboration and cooperation across institutional, political and geographic boundaries and by adopting river basin and IWRM approach. In the study, frame work of existing system is reviewed and data analysed to suggest pertinent IWRM plans that are to be approached by WUAs and authorities for better and improved river ecology in the Y drain system.

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1.0 INTRODUCTION

In the name of development schemes each Institution is taking up programmes and projects to suit its primary objective and overlooking the detrimental effects that may even harm its primary objective in long term. With regard to water resources schemes or projects, some of the pertinent questions for which getting proper answer is not easy. Such questions may be as below for which most of the times easy answer is in negative.

1. Who is the custodian of records to understand the geographical changes due to human interventions, like irrigation works, aquaculture, industrialization and urbanizations, SEZs etc.?

2. Are there any records on what is happening to our land and water resources?

3. Are there any review of effects on natural river systems because of ignoring watershed hydrology in existing irrigation systems?

4. Are there any reports on damage to hydro-ecology in a river basin?

5. Are there any studies on damage to hydro-ecology of natural drainage due to the introduced irrigation canal systems?

6. Are there any reports on restoration for safe guarding watershed hydrology in the existing irrigation systems?

Over the years a number of agencies, experts came with importance of IWRM and encouraging such approach in developing countries (AWWA. 1994; Biswas, A. K. 2004; Frederiksen, 1992; GWP 2004; Griggs, 2008; Wagner: World Bank. 1993).

Challenges for Managing Water Resources

Water has always been a scarce resource in any River basin at certain period of an year. Most of the precipitation falls during monsoon season and it is highly variable year-to-year, but the long warm summers are always dry. In the middle of 20th century, responsible agencies built a system of reservoirs, canals, pumps and pipelines to store water and deliver it to agricultural and urban users in dry areas. Also, significant investments were made in the flood protection projects to build flood banks and to divert by flood flow canals. These changes to the physical infrastructure have resulted in unintended consequences to the natural systems. Some of the challenges of such plans are as below.

Uncertain water supplies

Reductions in dependability of flows from major watersheds due to hydrologic and declining environmental conditions made water supplies less reliable. Moreover, climate change impact to these sources is a worrying aspect. These sources are crucial for our society to develop and manage local resources through strategies such as water use efficiency, recycled water, and groundwater recharge. Collective actions in this plan will contribute to more reliable water supplies.

Water scarcity/drought

Of late there is shortage of water supply during Rabi season especially when dry period extends. Improving our ability to manage scarce water supplies, especially when one encounters poor quality of groundwater aquifers in delta areas. Good coordination of major reservoir operations is essential to economic and environmental sustainability. Taking action to address drought is especially urgent for agriculture where crops wither without water.

Declining groundwater supplies

Groundwater accounts for more than one-third of the water used in habitations such as towns and cities, especially very much in dry years. Most of groundwater aquifers systems are not properly managed. Inconsistent and inadequate tools, resources and authorities make managing groundwater difficult in a given river basin and impede our ability to address problems such as overdraft, seawater intrusion, land subsidence, and water quality degradation. Pumping more than is recharged lowers groundwater levels – which makes extracting water more expensive and energy intensive. Under certain conditions, excessive groundwater pumping could mobilize toxins that impair water quality and cause irreversible land subsidence which damages infrastructure and diminishes the capacity of aquifers to store water for the future. When properly managed, groundwater resources will help protect communities, farms and the environment against the impacts of prolonged dry periods and climate change. The strategies identified in this action plan will support sustainable management of our groundwater resources.

Poor water quality

It is a fact that millions of River basins rely, at least in part, on contaminated groundwater or poor quality water due to water logging etc. Also, domestic wells are drying up in many areas. Right to safe, clean, affordable and accessible water adequate for human consumption, cooking and sanitary purposes is important. Safe water is necessary for public health and prosperity of the society. The methods set forth in this action plan will improve the organization of our water quality programs and create new tools to help ensure that every river basin has access to safe water.

Declining native fish species and loss of wildlife habitat

In any river basin where once robust native fish populations have thrived are now at or near historic lows. Central and state fish agencies now list many species fish as endangered and threatened. Wildlife habitat is also being lost at a rapid pace, due to reduction of flows into wetlands. Climate change further threatens the state's natural biodiversity. Tourism and fishing which provide economic benefits to local communities and to the govenments are also reliant on healthy ecosystems. The objectives in this action plan include aggressive ecosystem restoration and other steps that will restore fish populations and benefit wildlife.

Floods

A large population lives in rich flood plains of a river delta environment and one finds high population density here. Historically, flooding has occurred in all regions of the state. Due to climate change more precipitation will fall as rain and there will be more extreme weather events. This action plan will serve to coordinate and streamline flood control efforts and result in multi-benefit flood projects, helping to mitigate the significant investments needed to improve flood protection for existing communities and infrastructure.

Coping with the stress on river by IWRM

There is need to cope up with stresses on a given river basin. This is because basin water resources are committed and there are challenges posed by water quality and its scarcity. Societies respond to water shortage at basin scale and local scale in many ways, at both the individual and community level and the different basin regions. While the main emphasis is on the coping strategies of the state and technical expertise, the responses at different levels of society are often not included. In particular, local adjustments by individual users or groups of individuals and by local managers and officials are insufficiently recognized to replicate elsewhere. Integration across organizational level is essential as postulated by Grigg (2008) as shown in Fig. 1. Some typical IWRM plans to cope up are essential as uncoordinated actions and adjustments reverse the effect of measures undertaken at the macro level or even make them irrelevant. A first category of responses consists of augmenting the supply from existing sources (foremost, increasing the quantity of controlled water), as well as tapping additional sources. Typically, this is done by constructing new dams or sinking more tube wells and by diverting water from neighboring basins, desalinizing seawater, artificially recharging groundwater, etc.

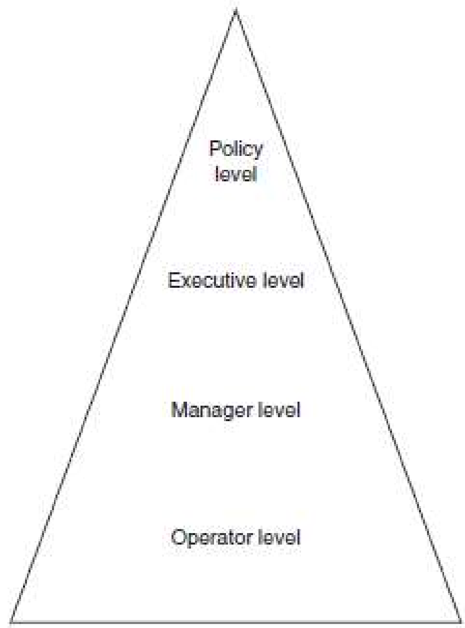

Fig.1 Pyramid of Integration across organizational level for IWRM

Thus, a review of present practices of IWRM in an area is important in order to prepare any IWRM based developmental plans to integrate different stake holders. In Andhra Pradesh a Farmers Management of Irrigation Systems Act was enacted in the year 1997. Groundwater development falls under AP WALTA Act. Accordingly, Water Users Associations and Distributory Committees were formed in the year 1997. To form Water Users Association (WUA) with the farmers, there will be managing committee consisting of 12 or 6 Territorial constituency members in major and medium WUAs/Minor WUAs and President and Vice President are elected by them. A workshop to interact with WUAs is organized in the Errakalva basin. They in turn elect distributary committee members who elect the Project committee members. There are also other self help groups with interest in fisheries and forest.

2.0 STUDY AREA

The Errakalva river basin has two distinct regions. The upper part is called Errakalva and the lower part below Nandamuru aqueduct is treated as Yanamadurru drain or Y-Drain in short by water resources agency and Weyyeru by local people as shown in Fig.2. The Y drain starts from Nandamuru aqueduct and empties in to Upputeru near Patapadu village and joins the Bay of Bengal. It has a catchment area of 900 sq miles or 2300 sq. km. partly in the mandal sof Tadepalligudem, Tanuku, Attili, Pentapadu, Ganapavaram, Palakoderu, Bhimavaram and Mogalturu in west Godavari district of Andhra Pradesh (Fig. 3). Soil map is at Fig. 4.

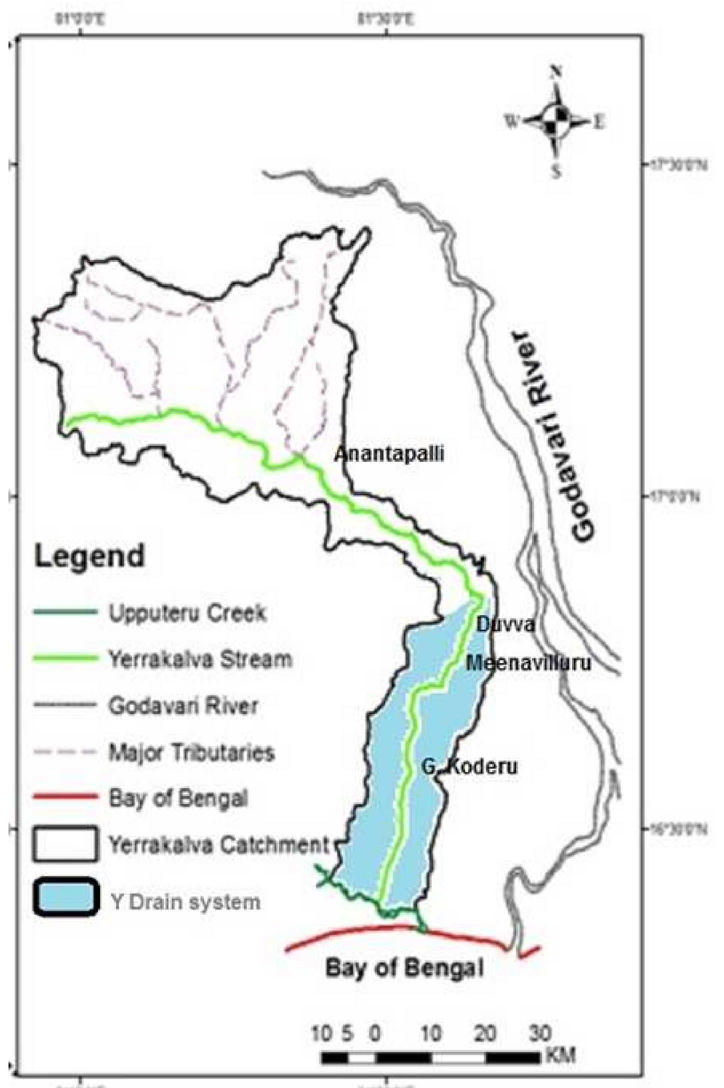

Fig. 2. Study area Y-Drain system in errakalva river basin

Surface water system

The most important and popular water resources project is the Godavari western delta main canal which starts at at Vijjeswaram from the head sluice of the Sir Aurthu Cotton barrage which more than a century and half. It crosses through an aqueduct over Y-Drain at Nandamuru. The course of Y Drain is freely used as part of delta canal system from here to Duvva regulator further down stream of Nandamuru. The flow diagram of the same is shown in Fig. 5. The Gosthani Nadi which joins Y-Drain near Gollakoderu is also made part of this canal system and drainage network, which carries irrigation return flows, local rainfall runoff and industrial effluents (Fig. 6). There is a gauge site at Gollakoderu. Thus, the stretch of Y-Drain between Nandamuru and Duvva is part of the Godavari delta canal system and there is lot of exchange of flows across its original catchment. Only except during floods in the Errakalva River basin or flood flows from local catchment, the Y drain river system carries reject water and effluents below Duvva regulator until it joins Upputeru or salt creek which Bay of Bengal. There is lot of tidal backwater effect upto Bhimavaram during high tide and or when storm surge is there.

Floods

The Y drain receives floods frequently and causes damages due to inundation in the deltaic plains, as most of the flood is choked at the under capacity aqueduct located at Nandamuru. The old aqueduct was designed for a discharge capacity of 243.5 cumecs and is substituted by new one with a capacity of 566 cumecs in 2003. Under CERP programme, the Y drain was improved to discharge 651 cumecs flood at the mouth. The maximum flood level recorded at the aqueduct on 5th October 1983 was +13.08 m and at Duvva regulator on 6th October 1983 was +10.12 m. The flood discharge at the regulator was 573 cumecs where as its design discharge is 470 cumecs. The flood events of severe intensity occurred in August 1986, July 1989, May 1990, August 2000 and September 2005, mostly due to cyclonic precipitation. As part of delta modernization project the Y drain is being improved to carry more flood discharge.

Fig. 3 The administrative Mandal locations in the study area

Fig. 4. The soil map of the study area

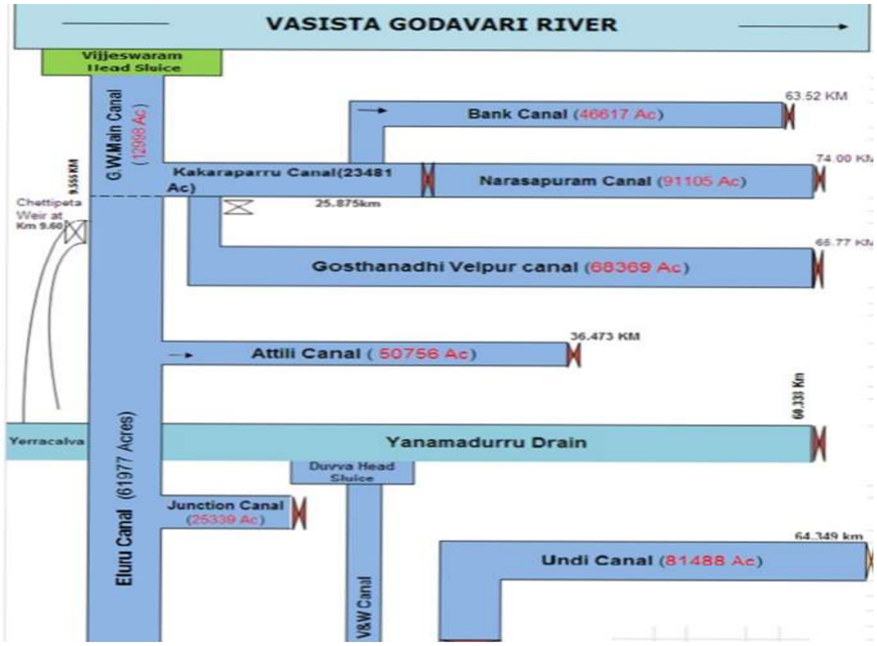

Fig. 5. The Surface water system of Godavari delta canals and Y-Drain

Fig. 6. The river flow down stream of Duvva Regulator on Y-Drain

Groundwater

From the groundwater prospects, the study area of Y-Drain is underlain by Recent Alluvium. In Krishna-Godavari delta the alluvium attains a thickness of more than a few hundreds of meters and the static water level in these formations is generally shallow (5 m). The geological of the study area is shown in Fig. 7. Groundwater in the coastal alluvium occurs both under water table and confined conditions and is generally developed by means of dug-wells, filter points and shallow tube wells. Usually the quality of water is the main problem in coastal alluvium. The unconsolidated formations are represented deltaic alluvium, coastal alluvium and inland river alluvium. The alluvial aquifers have high porosity and permeability. Filter points are most common in this formation. Filter points/Shallow tube wells drilled down to a depth of 15 to 70 meters below ground level (m bgl) yield between 250 to 400 lpm. The number of bore wells started proliferating after 1990 and subsequently the mean well yields started showing a decline with reduction in irrigated area or ayacut.

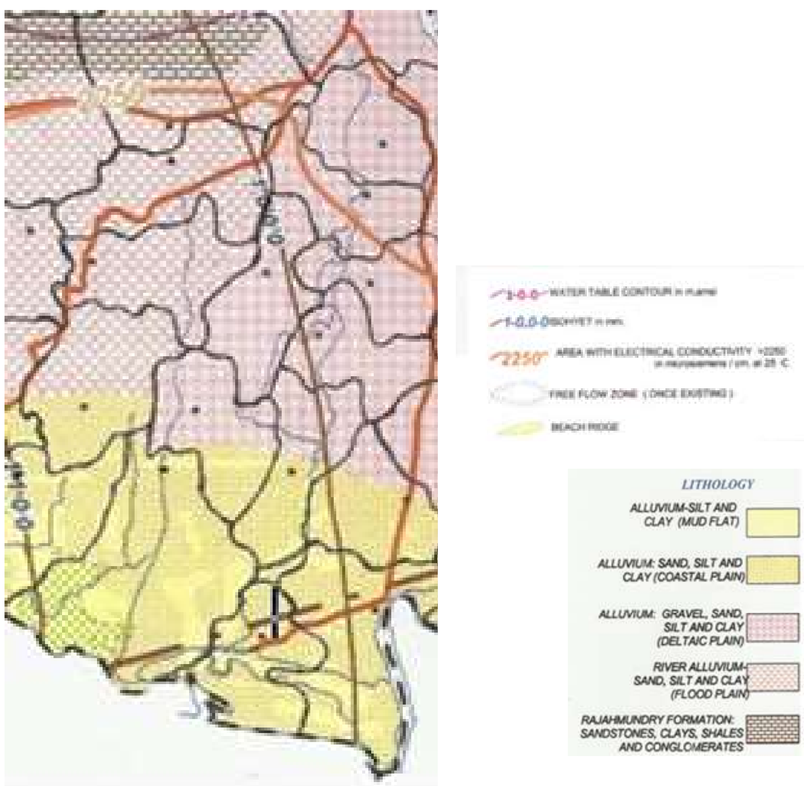

Fig. 7. The geological set up in study area of Y-Drain

Present day bore well takes 6 to 8 hours of excruciatingly slow pumping to irrigate the same field, which dug well used to irrigate in the past. The occurrence of groundwater and wells in the mandals in the study area is shown in Table 1 (CGWB 2003, GWD, 2011).

Table. 1 The manadal wise groundwater regime of Y-Drain system

Mandal	Extent %age alluvium	Weathered zone [m]	Fractures	Type of well[s]	Depth range of wells [m]	Yield range of wells [lpm]	Irrigation potential [area in hectares]]		Aqfuifer paratmers (Sp.Yield)
							Surface Water	Ground Water	
1	4	5	6	7	8	9	10	11	12
Tadepalligudem	20 %	-	'	STW, MTW, DTW	70-120	250-350	7306	11540	0.3
Ganapavaram	100 %	-	'	-	-	-		16336	0.2
Pentapadu	100 %	-	'	FP	20-30	-		19404	0.2
Tanuku	100 %	-	'	FP	20-70	-		10472	0.2
Undrajavaram	100 %	-	'	FP	20-30	-		9643	0.2
Attili	100 %	-	'	FP	15-20	-		13840	0.2
Bhimavaram	100 %	-	'	-	-	-		15503	0.2
Palakoderu	100 %	-	'	-	-	-		13882	0.2

Fresh water occurs as pockets and lenses in the top 20 mbgl in certain geomorphic units like paleochannels and dune-paleo beach ridges. However, the deeper aquifers are found to contain highly saline in nature. Deeper wells can lead to up-coning of salt water and fresh water interface, which can damage the groundwater irretrievably. It is also found that the sediments in these areas have connate water, which is not completely flushed out, and as a result the water quality is poor in deeper aquifers, mostly beyond 20 mbgl. In some mandals in deltaic region which has water logging or saline water ingress, groundwater is highly saline beyond water table depths, hence not suitable for both drinking and irrigation purposes.

Excess nitrates are reported from parts of almost all deltaic mandals of the distrct as isolated patches. However, in the Y Drain study area the quality is not so, except close to coast. In the study area, there is low ground water usage as per GEC reports where over all stage of ground water development <=30%. Accordingly, all the watersheds are in safe category as shown in Fig. 8.

Fig. 8. The groundwater development conditions Y-Drain system

Quality

Groundwater quality in general is found to be not suitable for irrigation practices in these areas since most of the irrigated area is covered with Godavari western delta and it is mostly water logged area. The groundwater quality varies from place to place and hence there may be pockets of better and usable groundwater quality. The variation in some chemical parameters are shown in Table. 2. In 14 numbers of full watersheds of the district viz., Nidamarru, Ganapavaram, Pentapadu, Undi, Akiveedu, Kalla, Bhimavaram, Palakoderu, Veeravasaram, Penumantra, Poduru, Palakollu, Narasapuram and Mogalturu are demarcated as poor groundwater quality areas. The total net annual groundwater availability in this area is 134246 ha.m. and in some places 309 ha.m. of this water is being used for domestic needs.

Table. 2. Groundwater Chemistry at select locations in the Y-Drain system

S. No.	Mandal	EC μS/cm	TDS (mg/L)	pH	Cl (mg/L)	F (mg/l)	NO_3 (mg/l)	General Quality for Drinking	General Quality for Irrigation
18	Tadepalligudem	505	323	8.89	40	0.00	3	Suitable	Suitable
26	Ganapavaram	970	621	9	60	1	2	Suitable	Suitable
27	Pentapadu	1260	806	9	150		30	Suitable	Suitable
28	Tanuku	700	448	9	80		5	Suitable	Suitable
29	Undrajavaram	5200	3328	9	1100		106	NO_3 Pollution	Unsuitable
32	Attili	1577	1009	8	210	0	35	Suitable	Suitable
36	Bhimavaram	470	301	8	60		7	Suitable	Suitable
37	Palakoderu	1690	1082	8	290		30	Suitable	Suitable

3.0 ANALYSIS AND RESULTS

As far as IWRM setup in the study area, it managed by Godavari western delta project committee, though it is part of drain the Yarrakalva river basin. This is because the Y –Drain system is made part of the Godavari delta canal system since more than a century. The study area has about ten Water Users' Associations (WUAs) and two Distributary Committees (DCs). In the study area WUA's are formed in December 2015 and recently most of the members are elected by consensus. Also, there are other stake holders from Fisheries and Rural Water Supply departments.

The river flow at the most down stream site on Y Drain at Gollakoderu gauge site over a period of 2000 to 2015 is analysed. They are compared with the flows observed at upstream Anantapalli site on Errakalva River for 2012-15. Extreme flows at G Koderu gauge site on Y Drain from 1999 – 2015 and corresponding discharges at Anantapalli site on Errakalva River for 2012-15 are shown Fig. 9.

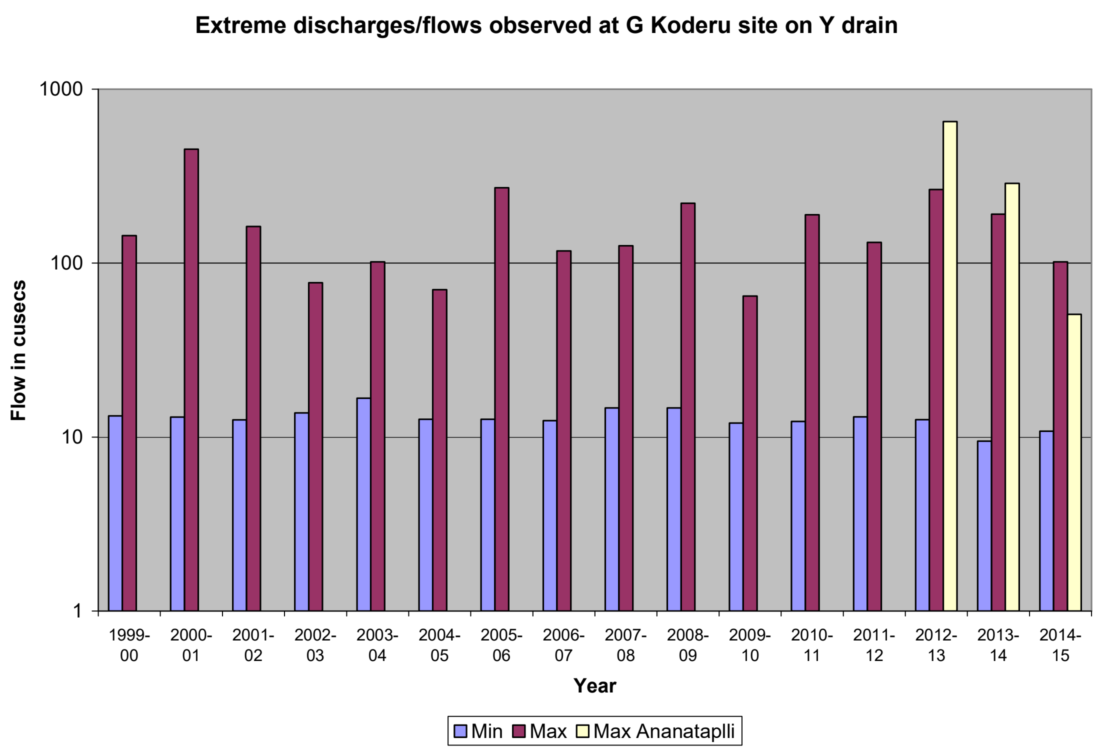

Fig. 9. Extreme flows at G Koderu gauge site on Y Drain from 1999 - 2015

The high flows recorded are shown in Table 3 to indicate the river influence on the flows. From the table it can be seen how a large flood recorded at upstream Anantapalli G/D site is getting regulated at the down stream site. This is causing flooding in the upstream and there is conflict between upstream WUAs and down stream WUAs. Observed peak river hydrographs at two gauge sites on Errakalva basin at Anantapplu up stream site and Gollakoderu down stream siteo (on Y Drain) during November 2012, October-Novemeber 2013, and in July-August 2014 is shown from Fig. 10 to Fig. 12 respectively. It shows that the Gollakoderu site records higher river flow during July-August when actually the Godavari river has good flood flows due to the surplus at the hydro electric plant on the Western delta main canal at Settipeta wier works full and also sue to water that spill the surplus wier.

Table 3. Extreme flows at G Koderu gauge site on Y Drain from 2011-15

Year	2011-12	2012-13	2013-14	2014-15
Max	131.5	265.1	191.2	101.8
	26-Aug	06-Nov	29-Oct	29-Jul
Min	13.06	12.59	9.49	10.81
	06-Jun	25-Jun	28-Jun	25-Feb
Max Ananataplli (U/s)		650.5	287.6	50.84

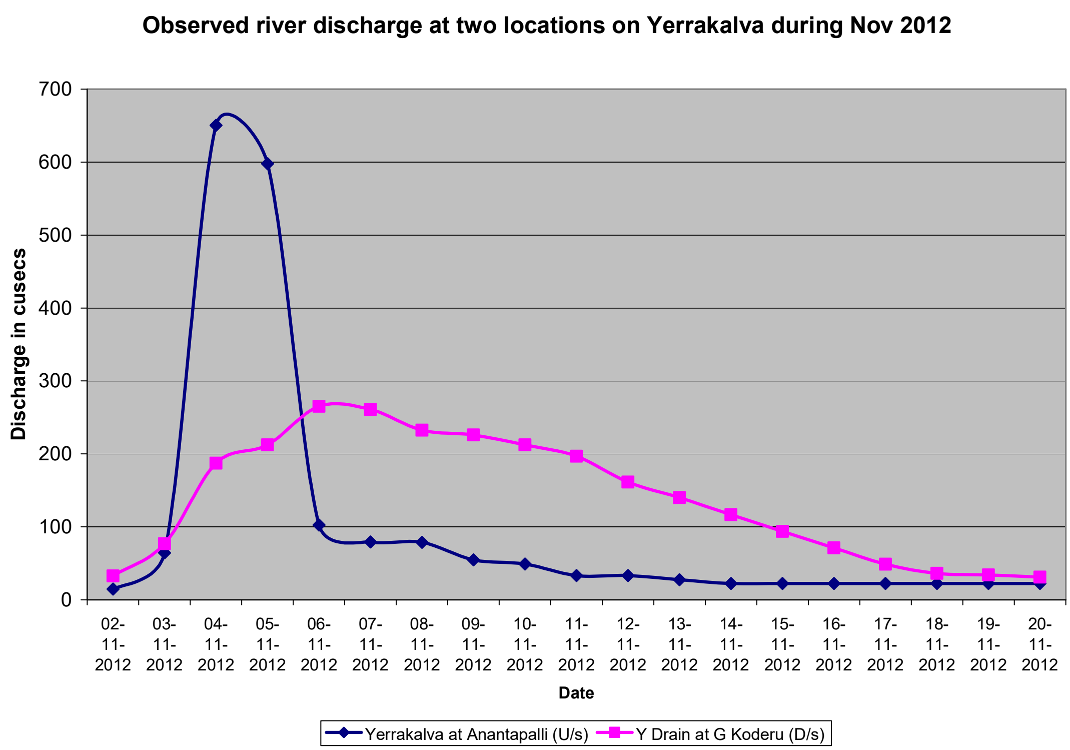

Fig. 10. Observed river flows during November 2012 at two sites on Errakalva and Y Drain

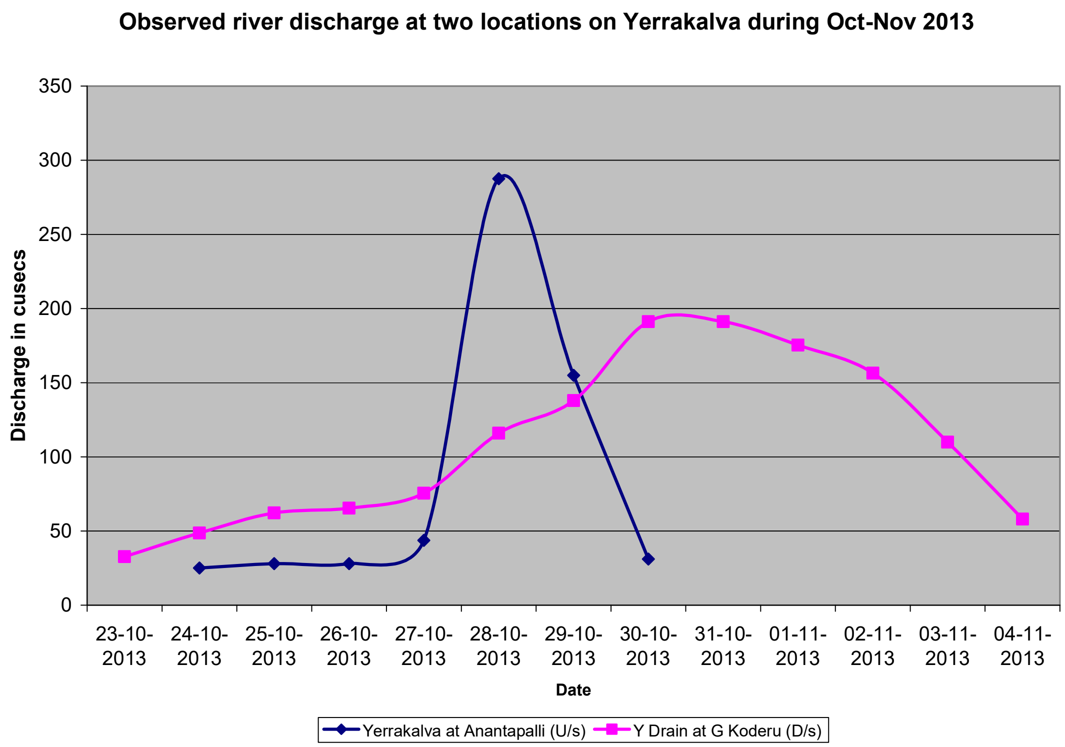

Fig. 11. Observed river flows during Oct- Nov 2012 at two sites on Errakalva and Y Drain

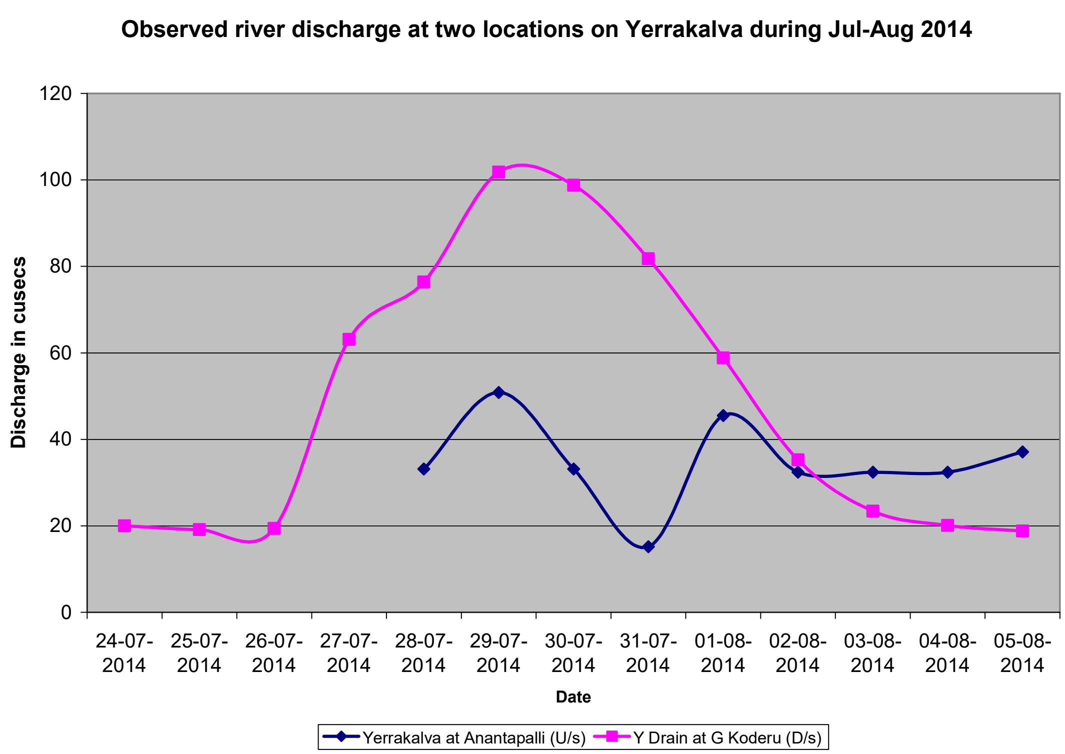

Fig. 12. Observed river flows during Jul- Aug 2014 at two sites on Errakalva and Y Drain

Water availability

The Y drain receives very limited runoff from upstream as it is mostly diverted at Yerrakalva Res. Project near Janga Reddy Gudem and through river head channel below, that feed tanks, except during flood time. Most of the flows are from hydel station at Chettipeta wier on Eluru canal of Godavari western delta canal system under SAC barrage. These flows from Godavari canal join the yerrakalva near Nandamuru aqueduct and are again diverted from Duvva head sluice into Venkayya Weyyeru Canal that irrigates most of the deltaic plains of west Godavari district. Below the cross regulator on NHAI bridge near Duvva, the Y Drain is part of the Upputeru major drainage system that discharges irrigation return flows of the command area under Undi Canal receiving water from Duvva regulator of Godavari canal system.

Return flows and effluents

These flows of Y drain are gauged at Gollakoderu gauge site located downstream of the confluence of Gostanadi Drain, that receives irrigation return flows of Velpuru and Attili Canals that of take from Eluru canal of Godavari canal system. Along with irrigation return flows and flushing from aqua ponds some industrial effluents also contribute to the river discharges at the gauge sites. The Y drain receives base flow and effluent flow during the months of April, May and June and in further lower reaches backwaters through creeks connected to sea and Upputeru. Hence, the water quality of Y Drain deteriorates below the confluence of Gosthani Nadi during lean season in lower reaches towards its mouth.

Water requirements

The water requirements are met from the Godavari Western delta canal system in command areas draining Y drain. There is enough canal water available during kharif and rabi seasons for agriculture (75%), fresh water aqua culture (10-15%), industrial use and drinking water (10%). Thus, the groundwater resource estimates indicate that the resource development is in safe level. In lower reaches close to coast the groundwater is saline and used for brackish water aquaculture. As is the scenario in most basins, the environmental flow requirements are not maintained as the needs of the ecosystem are not cared for any stake holder.

Suggested IWRM hydrological plans

Increasing population and ensuring its food security and changing social values made it very difficult to manage available surface and ground water supplies in many areas due to competing economic and ecological demands on water. This has increased the conflicts and complexity among its users and users or stake holders. Also, there are challenges of unpredictable climate, old and often inefficient infrastructure, lack of water budget data regarding water supplies and demands, confusing water rights and ever changing regulations or governance issues. Hence, assuring a secure water future is becoming more costly and increasingly uncertain. To effectively develop and manage water resources from local to national level, there is necessity for stronger collaboration and cooperation across institutional, political and geographic boundaries and by adopting river basin and IWRM approach. The following IWRM plans are to be approached by WUAs and authorities for better and improved river ecology in the Y drain system.

1. Yerrakalva reservoir storage and Eluru canal water is to be managed to provide multi-use benefits and flexibility.

2. Taking up artificial recharge to improve groundwater storage in mutli layer aquifer systems

3. Improving irrigation efficiencies by gong for higher duties to check irrigation return flows. The conserved water can be used to stabilize poorly irrigated areas or for drinking and industrial uses in urban centres.

4. Splitting water to be delivered for agriculture and aquaculture occasionally for in-stream releases and rejuvenation of the streams of Y Drain system to keep enough water in the lean season in the Y Drain for fish to the satisfaction of environmental and ecological requirements.

5. Conjunctive use of groundwater and surface water in space. To use groundwater in upland and middle portion in the Y Drain system to assure enough canal supplies in lower and tail end reaches for agriculture and also help check salinity ingress along the coast.

6. Development of systematic collaboration of stakeholder so that their involvement is in real time and will help review and check any delays in provision of enough water and pilferages in the Y drain system.

A review of present practices of IWRM and methods of preparing developmental plans to manage different stake holder has been reviewed. The existing setup for IWRM in the study area is compiled.

4.0 CONCLUSIONS AND RECOMENDATIONS

Due to u/s diversions at Duvva regulator, the contribution from irrigation return flows and base flows has significant effect on quality of stream flows down stream. Further down stream with the confluence of Gosthanadi with Y Drain though there is increase in river flow its quality is dominated by the effluents from Gosthanadi apart from that of irrigation retuen flows and base flows. It is observed that due to unilateral way of providing irrigation for 2 to 3 crops in the with the study area which is part of Godavari delta command area system, there is interference with natural flows in Yerrakalva river and on its drainage, that has gone unnoticed.

The water resources department itself is the custodian as conservator of the stream and only should be aware of the importance of allowing sufficient discharges to maintain river eco system. As a regulator of canal water supplies, 15-20% of mean annual flows (MAF) of Yerrakalva river basin towards EFR may be regulated below the Duvva regulator and in Gosthani nadi drain from suitable regulators on Velpuru and Attili Canals for rejuvenation of Y drain system.

From the interactions nade with WUAs, investigations carried out and analysis of data a few IWRM plans are suggested to be adopted by all stake holders in the Y-Drain system towards improving the present isolated practices. Such an approach may result in improved river ecology in the Y drain system and for sustainable water resources development.

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