Distribution of Water Harvesting Structures in Chevella Basin, Telangana State, India

Ramesh Penumaka[1], Sankara Pitchaiah Podila[2]

Department of Geology, Nagarjuna University, Guntur, Andhra Pradesh, India

Abstract: ***A watershed provides a natural geo-hydrological unit for planning any developmental initiative. The approach would be treatment from "ridge to valley". The present study has made on the observation of Chevella basin to identify the suitable locations and to suggest appropriate RHS. The basin occupied with black soil mixed with calcareous and gravel. Geomorphic units identified are moderately dissected plateau, shallow weathered plateau, shallow valley fill, slightly dissected plateau, pediment and inselberg. 419 locations are marked for the construction of various RHS. Out of this it is suggested to construct 41 percolation tanks, 189 check dams, 35 check walls and four farm ponds, one earthen bund and 149 rock fill dams. It is felt that community participation is essential for the successful implementation of watershed development program.***

Keywords: watershed development, rain water harvesting structures, earthen bund, farm pond, percolation tank, check dam, check wall, rock fill dam

1. Introduction

A watershed can simply be defined as any surface area from which rainfall is collected and drained to a common point (Li et al., 2005). It is synonymous to a drainage basin or catchment area. Each watershed has a unique combination of inherent conditions, use and management, and the response to flow and water quality is highly variable and complex (Adams et al, 1998). Watershed serves as effective natural unit to monitor the processes that influence the integrity of the functioning ecosystem. Wani et al., (2006) Watershed is not simply the hydrological unit but also sociopolitical ecological entity which plays crucial role in determining food, social and economic security and provides life support services to rural people. Agarwal (2006) explained the technology based integrated watershed develop model. The model highlighted the role of NGOs and networking needs for interfacing with science and technology institutions and support agencies and system approach for technology-based integrated watershed development. Budumuru and Gebremedian, (2006) pointed that participatory watershed management projects have been raising income, agricultural productivity, generating employment and conserving soil and water resources. A watershed management provides a natural environmental unit for planning a developmental initiative (Thorat 2017).

Watersheds are classified (Table 1) into a number of groups depending on the size, drainage, shape and land use pattern (Slusi.dacnet.nic.in).

Table 1: Classification of Watersheds

Category of Watershed	Size (ha)	Average size
Water Resource Region	270,00,000- 1130,00,000	5,50,00,000
Basins	30,00,000 - 300,00,000	95,00,000
Catchments	10,00,000 - 50,00,000	30,00,000
Sub catchments	200,000 - 10,00,000	7,00,000
Watersheds	20,000 - 300,000	1,00,000
Sub watersheds	5,000 - 9,000	7,000
Micro watersheds	500 - 1,500	1,000

In India many researchers carried out studies on watersheds. The studies are on one or more aspects i.e., Rain Water Harvesting Structures (RHS), development of water quality and quantity, crops and yields and socio economic impact- Karnataka: Katar Sing (1989), Deshpande (2003); Orissa: Satpathi (1989), Souvik Ghosh (2004); Tamilnadu: Arul Gnana Sekar (2001), Chandrasekaran et al., (2002); Maharashtra: Mahandule (1991;) and Gujarat: Shiyani (2002) and Srivastava (1991).

Chevella watershed of Ranga Reddy district in Telangana State is one of the drought prone basins in the state. Geographically Chevella lying between East longitude 78^0 04′ 10" and 78^0 13′ 58" and North latitude 70^0 26′ 50" and 70^{0}17′ 52". Figure 1 shows the location of Chevella watershed. The basin is spread over 23 villages of two mandals i.e., Chevella and Shankarapalli.

Figure 1 (a): Location map

Groundwater is the main source of irrigation in the basin. The groundwater potential is meager in the basin. Water levels in the basin varying between 5m to 13 m with seasonal fluctuation of 2.0 m to 8.0 m. Types of groundwater abstraction includes dug wells, dug- cum- bore wells and bore wells. Means of abstraction includes diesel pumps, electrical mono pumps, submersible pumps and purpose of abstraction includes domestic needs, drinking water and irrigation. The increasing exploitation of groundwater during the last two decades and deficit in the rainfall for the last few years has driven the farmers to a distress situation and migration. The Central and state governments along with Voluntary Organizations have been implementing various Watershed Projects like D PAP, EAS, IWDP, DDP and now IWMP (DPAP, IWDP and DDP merged) with the involvement of communities. The present study is aimed at studying the suitable locations and appropriate RHS for construction to develop the groundwater resource, production of high yields and to improve the socioeconomic status of the people.

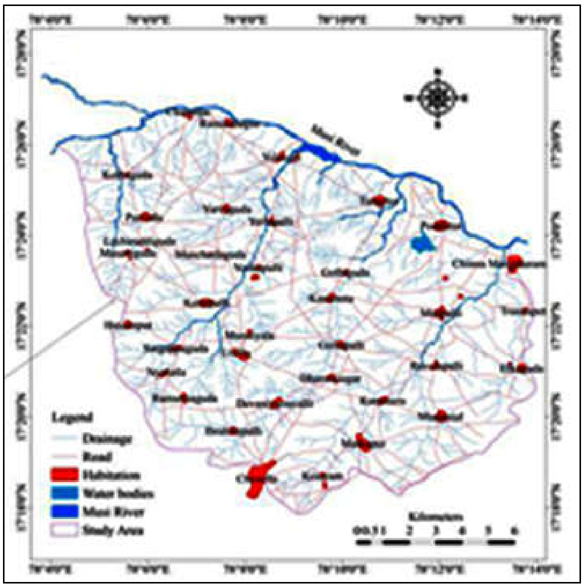

Figure 1 (b): Chevella basin

Climate, Geology and Geomorphology

The Chevella is under semi-arid condition and come under Southern Telangana Zone agro-climatic zone (Agriculture Action Plan 2016-17, Department of Agriculture). Average annual rainfall over the period of fifteen years is 831.4 mm. Maximum temperature varies from 28°C to 42° and the minimum 13°C to 28°C.

The basin occupied with black soil mixed with calcareous and gravel. It has loamy texture. It has moderate to severe erosion characteristics extended to very deep. (CDAP, 2005-06). Geology of the area is shown in table 2.

Table 2: Geology of Chevella Watershed

Lithology	Formation	Era	Characteristics
Laterite		Pleistocene	Moderately hard and porous
Basalt, Intertrap-pean	Deccan trap	Cretaceous to Paleocene	Parallel layered, steep topography
Predominantly granite and alkali feldspar granite	Peninsular gneissic complex	Arche-an	Hard, Compact

The major geomorphic units in the area are moderately dissected plateau, shallow weathered plateau, shallow valley fill, slightly dissected plateau, pediment and inselberg. In the basin three types of plateau weathered shallow (PLWS) hydro geomorphic units are formed in massive basalts of Deccan traps. These for are classified based on the depth to water level and yield of wells in a particular area. PLWS-352 and PLWS - 353 are located at south tip; whereas, PLWS – 354 are occupied major part among other similar land forms at extreme east and north of the basin. Two types of Plateau slightly dissected (PLS) land forms are found at different parts of the basin. PLS-353 are found entire basin and PLS-354 are located at north surrounded by PLWS-354. Recharge pits and check dams are the suitable structures in this type of area. Weather zone over basalts act as recharge zone and the underlying fractures act as aquifer in the PLS land forms. Quartz vein formed as Linear Ridge (LR) is found as isolated hills at west of the basin. These vein acts as run off zone and as a barrier for groundwater movement. Valley fills (VFS) are formed along drainage course of first and second order drainage. Valley fills are filled with loose material act as a good recharge zone. The underlying fractured rocks act as an aquifer. Check dam are the most suitable water harvesting structures in this zone. Pedi plain moderately weathered (PPM-812) and pedipalin shallow weather (PPS - 812) is occupied along streams of the basin.These are formed in granite area. Area of PPM-812 is moderately good recharge area and can be expect along the weathered and fractured zone. Check dams and recharge pits are suitable in this type of area. PPS-812 have characterized as limited yield along the weather zone and fracture zone. Pediment zone in the Chevella area has occupied around the streams. It has limited yields along fracture zone (Ramesh and Sankara Pitchaiah 2017).

Average annual rainfall over the period of fifteen years is 831.4 mm. Around 2,637 wells including open wells and dug wells are dugout in the Chevella area. Out of this 1,778 are bore wells and remaining 859 are dug wells. The basin is drained by Mussi River located along northern boundary of the basin. The drainage pattern of the basin is sub dendritic to sub parallel which indicate that the area is hard and porous in nature.

2. Methodology

The basin is consisting of 23 villages and each village has marked as a micro watershed. One of the authors interacted with the different stakeholders i.e. farmers, agricultural labor, self-help group members, watershed committee, watershed association members, Department of Agriculture, Irrigation and Social forestry About 225 members are interviewed covering all the villages with prescribed format and recorded their socio-economic condition and impact of the watershed in their villages. Locations of RHS are Identified in the basin by transect walk from ridge to valley covering streams, tributaries, slopes, common property resources (CPR) and individual lands. At each structure dimensions like length, width, and depth/height of the structure are measured for estimating the quantity of the water harvested and estimating the recharge from the structures.

3. Results and Discussion

Agriculture is one of the major livelihood activities in India and around 75% rural population depends up on agriculture and allied activities; it plays a vital role in our country's economy (Saxena, 2008).

Watershed programmes promoted participation by villagers were found to be far more successful than those focused solely on technical interventions (Kerr 2002, Palanisami et al. 2009). Ahmad et al., (2011) analyzed that the watershed programme aim to restore degraded watersheds in rain fed regions to increase their capacity to capture and store rainwater, reduce soil erosion and improve soil moisture.

Garg et al., (2012) felt that the watershed development program is for increasing agricultural production and income and there is a need to understand various trade-offs between upstream and downstream locations.

Shivasharanappa et al., (2013) due to construction of different structures from ridge to valley, dilution of the water groundwater quality might be change in post monsoon in the watershed programme implemented areas. Suraj Bhan (2013) revealed that the watershed management has shown the potential of doubling the agricultural productivity, increase in water availability, restoration of ecological balance in the degraded rain fed ecosystems by greening these areas and diversification of cropping farming systems. Mukharjee (2016) suggested that the quality of groundwater can be improved by recharging with high quality injected water by construction of artificial recharge structures like check dams, percolation tanks, farm ponds sunken pits etc.

Rain Water Harvesting Structures

There are different techniques of rainwater harvesting which can be adopted to make use of storage of water. In-situ rainwater harvesting techniques like tillage practices; trenches etc. make use of the soil medium to store the harvested rainwater. Excess of the storage capacity of these practices flows downstream as surface runoff. This runoff can be harvested by rainwater harvesting structures. The harvested water percolate into the deep portions of the subsurface and joins the groundwater table which makes increasing of groundwater levels and cropping land in the watershed.

Identification of location and type of RHS

Across the Chevella watershed 419 locations (Figure 2) are identified and suitable RHS are suggested, which are constructed later. Out of this 41 are percolation tanks, 189 are check dams, 35 are check walls and four farm ponds, one one earthen bund and 149 are rock fill dams (Table 3).

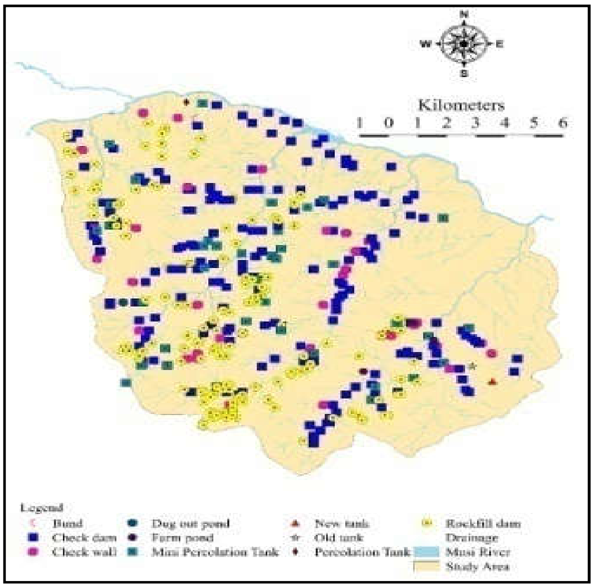

Figure 2: Location map of Rain Water Harvesting Structures (RHS)

Table 3: Village wise and category wise RHS number

Village	1	2	3	4	5	6	7
Chandippa	1		2	1	2	6	**12**
Devunierravally			1	5	2	10	**18**
Gollapally			1	4	1	6	**12**
Hussainpur		1		3	1		**5**
Ibrahimpalli				6	1	31	**38**
Kammeta			1	11	6		**18**
Kesaram				6		1	**7**
Kothapalli			3	11		3	**18**
Kummera		1	1	5	2	5	**14**
Malkapur			2	10	1	9	**22**
Masaniguda			2	9	3	1	**15**
Ravulapally		2	2	11	2		**17**
Mudimiyala			3	10	4		**17**
Nyalata			5	10	4	18	**37**
Parveda			3	13	1	20	**37**
Proddutur			1	3			**4**
Ramanthapur				2			**2**
Tangatoor				16			**16**
Urella			5	16	3	28	**52**
Elverthy				11	1		**12**
Yenkapally			6	7		3	**16**
Yarlapally			3	6		8	**17**
Yervaguda				13	1		**14**
Total	**1**	**4**	**41**	**189**	**35**	**149**	**419**

1-Earthen bund, 2-Farm pond, 3-Percolation tank*, 4- Check dam, 5- Check wall, 6- Rock fill dam**, 7- Total
* Percolation tank includes Mini Percolation tanks **Rock fill dam includes Loose boulder structures and Water Harvesting Gabion

The following structures (Figures 2.1 to 2.7) are constructed with the available local material and low cost technology in the Chevella watershed. They are earthen bund, rock fill dams, loose boulder structure, water harvesting gabion, farm pond, percolation tanks and check dams. Earlier, check walls are constructed with wood but damaged during the time. The details are briefly presented here.

Earthen bunds

It is one of the popular soil conservation structures and is practiced at large scale in all Chevella watershed villages. The bunds (Figure 3.1) are constructed on agricultural land with the aim of arresting soil erosion and improving the soil moisture. They would lie along the boundary of the field. The soil erosion from the field is reduced and the waste weir in the field helps for safe disposal of the excess water from the field.

Farm Ponds

The main objective of farm pond (Figure 3.2) is to store the water from the surface runoff in the ponds and use for the irrigation purpose. The water stored in the farm ponds is generally used when the rains are irregular.

Percolation Tanks

The percolation tanks are artificially created surface water bodies, submerging a land area with adequate permeability to facilitate sufficient percolation of impounded surface runoff (Figure 3.3). These structures are recognized as a dependable mode for groundwater recharge in the hard rock terrain. The hard rock areas with limited to moderate

Figure 3.1: Earthen bund

Figure 3.2: Farm pond

water holding and water yielding capabilities often experience water scarce situations due to inadequate recharge, indiscriminate withdrawal of groundwater and mismanagement. A tank can be located either across small streams by creating low elevation check dams or in uncultivated land adjoining streams, through excavation and providing a delivery canal connecting the tanks and the stream.

Figure 3.3: Percolation Tank

Check dams

These are small scale, low cost structures (Figure 3.4), generally built across a small stream to store the rain water from flowing away. They check the velocity of water, reduce the erosive force of water, store water in stream courses, increase groundwater recharge and increase soil moisture conditions (Murty, 1998). This harvested water provides direct irrigation for the surrounding areas, through direct lift and ground water percolation (Shingi and Asopa, 2002).

Figure 3.4: Check dam

Rock fill dams

A rock-fill damis a small, temporary or permanent dam constructed across a drainage ditch, swale, or channel to lower the speed of concentrated flows for a certain design range of storm events (Figure 3.5a). A check dam can be built with wood logs, stone, pea gravel-filled sandbags or bricks and cement (RUFFINO 2009). Reduced runoff reduces erosion and gully erosionin the channel and allows sediments and other pollutants to settle out.

Loose Boulder Structures

This is also a type of Rock fill dam aimed to reduce the soil erosion of soil on the upper side of the catchment area. By constructing the bunds with rocks across the gully the velocity of runoff and soil erosion can be reduced and water percolates in to the soil (Figure 3.5b). Gradually the gully will be filled with the silt and the area can be brought for cultivation in the field. It can be constructed at low-cost and with locally available materials.

Water harvesting Gabion

It is similar to lose boulder checks, but are constructed across bigger streams and have their own catchment area. These structures can be constructed on flatter regions. The flatter the upstream slope, the more will be the storage.

Figure 3.5 (a) Rock fill- dam

Figure 3.5 (b): Loose Boulder Structure

Along with slowing down the runoff these structures also help to store the water temporarily, if the bed is impermeable. The structure is generally reinforced with wire mesh for stable embankments which oppose strong currents (Figure 3.5c). The bunds made by covering the loose stones by mesh are called "Gabion Bandhara" The areas where the slope of the nala is greater than 3% and the rainfall is heavy in such conditions the loose boulder structures cannot sustain, so in such cases the Gabion Bandhara are preferred.

Figure 3.5 (c): Water harvesting gabion

Village wise RHS structures

Village wise details about the streams flowing adjacent, number and locations of RHS and the distance from the village are given in Table 4.

Table 4: Village wise details about streams and RHS

Vill-age	Streams	RHS	Distance (km)
1	Kathvagu, Sakavagu	EB-1S; PT- 2S; CD:1 S; CW-2S; RFD -6S	0.75 to 2.75
2	Nakkalavaduka, Peddavagu, Lingaiahvagu Doyyavaduka and Kandinavaduku	PT- 1N; CD:5 N,S,E; CW-2 E,W ; RFD -10-Across Peddavagu and Kandinavaduku	0.5 to 2.0
3	Indodivaduka, Pedavagu and Mysammavagu	PT- 1 E;CD:4 S; CW-1 W; RFD -6 N,E	0.5 to 3.0
4	Naagambhavi and Saakarvagu	FP-1 S; CD:3 N,S; CW-1 S	0.5 to 1.5
5	Mamillavagu, Peddavagu, Chintachettugaddavagu, Danduvani -vanka, Madd-igaddavanka and Sonnapollagaddavaduka, Anga- dibavivaduka, Mamidichettuvaduka, Kammaro- nivanka and Jaju- gaddavanka	CD:6 N, E ,W CW-1 N ; RFD -31 N,W,E,S	0.3 to 2.0
6	kathvagu, Saka- vagu, Dhoneva- duka, Joluvagu, Pedavagu, Chinn- akanch, Modipaluvagu, Gaddalavaduka, Monmonvaduka, Samallavaduka and Ravulapalli- vaduka	PT- 1 S ;CD:11 N,S, E,W; CW-6 N,S, E,W; CD-11 N,S, E,W	0.2 to 1.9
7	Naagambhavi and Saakarvagu	CD:6 N,W,S RFD -1 W	0.5 to 1.5
8	Naagambhavi and Saakarvagu	PT-3 N,S,W CD:11 N,W RFD-3 W	0.5 to
9	Yellammakatuva, Odlonivaduka, Jakkanimakta, Madigonivagu, Kammaroni- vaduka, Buchaiahvoduka and Bheerappa- voduka	FP-1; PT-1 N CD:5 N,W,S CW-2 N; RFD -5 N, S, W	
10	Dumukudu bonda, Kammaro- nivadaka, Chinta- vadaka, Peethrivaduka and Seri vaduka	PT- 2 E,N; CD:10 N,S,E, W; CW-1 S RFD-9 N,S,W	0.25 to 2.0
11	Jangamonivagu, Dunkudubonda, Dimpalagadda, Harevagu, Chinta- mysammavagu and Mysamma- vagu	PT-2 N,E,W; CD:9 N,S,E,W CW-3 N,S,E RFD-1 in the village	0.4 to 1.6
12	peddavagu, Yellammavagu and Musalamma- vaguPedavagu, Maktabhavi, Kottacheruvuvaduka, Gorilaguddu-vaduka, Gopaiah- vaduka, Guttala-vagu and Kuntalavaduka	FP-2 E; PT- 5 E,SE; CD:21 N,E,W; CW-6 W	0.25 to 1.5
13	Bandalavaduka, Sirilavaduka, Tummalavaduka, Gopaiahvaduku, Maktabhaviva- duka, Kanugula-vaduka, Sirila-vaduka, Pedavagu, Dongalavaduka, Molkaranivaduka,Kolbhaivaduka, Chinnavaduka, Veukavaduka and Chelimoluvaduku	PT- 5 N,S, W CD:10 N,S CW-4 N,E,W RFD -18 N,S, E,W	0.3 to 1.5
14	Thontollaloddi, Kavalolaloddi, Erkalaiahvagu, Hare vagu, and Marla bhavi, Loddivodaka, Jeelugaddalavaduka, Erkalaih- vaduka and Firangivaduka	PT- 3 E; CD:13 N,S; CW-1 N RFD -20 N,S, E,W	0.5 to 3.5
15	Peddavagu	PT- 1 S; CD:3 E,S;	0.5 to 2.0
16	Gollavagu	CD:2 N,S	1 to 1.5
17	Peddavagu, Yellammavagu and Musalamma- vagu	CD:16 ; ,S,E,W	0.5 to 2.0
18	Karokollamurri, Devunivaduka, Tolukuntavagu, Oorumundu-vaduka, Bhadra-ppavaduka, Bokalavaduka, Misabvaduka, Hindodhva-duka, kareemsahebvoduka	PT- 5 N,NE,S CD:16 ; N,S, NE,W; CW-3 N, E, W; RFD -28 N,S, E, W	0.4 to 2.0

	and kolafarm-vaduka		
19	Karokollamurri, Devunivaduka, Tolukuntavagu, Oorumundu vaduka, Bhadra-ppavaduka, Bokalavaduka, Misabvaduka, Hindodhvaduka, kareemsahebvoduka and kolafarm-vaduka	CD:11 N, S, E CW-1 S	1 to 3.0
20	Kisaguntlavagu, Mondivagu, Peddavagu, Gennerlavagu, Chinnakuntavaduka and Paanadi-vaduka	PT- 6 S,E; CD:7 N,S,W RFD -3 S, E	0.4 to 1.5
21	Gundaguvaduka, Chenganna-vaduka, Balaiah-vaduka, Malaposha- mmavaduka, Pothaguvaduka and Oorumandu- vaduka	PT- 3 S, E CD:6 N,S, E, W RFD -8 N,S, E, W	0.5 to 1.5
22	Gundaguvaduka, Chengannava- duka, Balaiah-vaduka, Malapos-hammavaduka, Pothaguvaduka and Oorumandu-vaduka	CD:13; ,S,E,W CW-1 W	0.5 to 2.5

4. Recommendations

- Provide the capacity building trainings to all the stakeholders
- Create corpse fund for landless poor for their thrift and credit activity for enhancing livelihood
- Identify the works from ridge to valley with the support of local farmers through transact walk
- Participatory approach in planning and execution of the program will be delivered best results in terms of quality and quantity
- The local farmers should take the responsibility of maintenance of existing structures
- Farmers should follow the water use efficiency methods
- Micro level water availability and demand assessment will be useful to sustain the water resources
- Capacity building to the farmers on water resources is highly required in the all watershed implementing area

5. Conclusion

Implementation of Watershed programme is one of the best approach for re-generation of natural resources; control the soil erosion, improve the soil moisture& groundwater, improve the agriculture yields, provide the employment, control the migrations, better livelihoods for the rural poor and reduce the poverty in the country. The surveys shall be continued throughout the state in all the watersheds to identify the suitable locations and RHS for the betterment of the rural people.

6. Acknowledgment

The authors are thankful to Ms. Nazia Sultana, Research scholar, Department of Geology, Acharya Nagarjuna University, Guntur for her help in preparing the manuscript.

References

[1] Adams, (1998) Aquifer susceptibly to side-effects of groundwater exploitation. 71–76 in Groundwater pollution, aquifer recharge and vulnerability. ROBINS, N S (editor). Geological Society of London Special Publications, No. 130. ISBN1-897799-98-5.
[2] Agarwal, (2006) http://shodhganga.inflibnet.ac.in/bitstream/10603/148780/7/07_chapter%202.pdf.
[3] Ahmad, J., Alam, D., Haseen, S., 2011. Impact of climate change on agriculture and food Security in India‟. International Journal of Agriculture, Environment and Biotechnology. Vol. 4 (2): 129–137.
[4] Arul Gnana Sekar (2001), Arul Gnana Sekar,S. (2001) “Micro Watersheds and Agriculture – A Case Study”, Journal of Extension and Research, Vol. III , No. 1, Pp.25-30.
[5] Budumuru and Gebremedian, (2006) http://shodhganga.inflibnet.ac.in/bitstream/10603/84447 /9/09_chapter%202.pdf
[6] Chandrasekaran, Palanisami K, Suresh kumar D, and Chandrasekaran B (eds) (2002) Watershed Management: issues and Policies for 21st Century, New Delhi, India: Associated Publishing Company Ltd.
[7] Debu Mukherjee, (2016) A review on artificial groundwater recharge in India, SSRG, International Journal of Civil Engineering, Volume 3, Issue 1.
[8] Deshpande, R. S., M. J. Bhende and S. Erappa, (2003), "Output and Impact Monitoring Study of KAWAD Pr).
[9] Garg Kaushal K, Suhas P Wani, Jennie Barron, Louise Karlberg and Johan Rockstrom (2012) Up-scaling potential impacts on water flows from agricultural water interventions: opportunities and trade-offs in the Osman Sagar catchment, Musi sub-basin, India, Hydrol. Process. Published online in Wiley Online Library (wileyonlinelibrary.com) DOI: 10.1002/hyp.9516.
[10] Karam Singh, (1989). Dry land watershed development, a case study in Karnataka, Indian Journal of Agricultural Economy 46, pp 121-131.
[11] Kerr, J., Pangare, G., and Pangare, V.L. (2002). Watershed Development Projects in India-An Evaluation Research Report 127. International Food Policy Research Institute. Washington, DC: International Food Policy Research Institute.
[12] Kushal K.Garg and Suhas.P.Wani, (2012). Opportunities to Build Groundwater Resilience in the Semi-Arid Tropics. Ground Water. pp. 1-13. ISSN 1745-6584
[13] Li Q, Lgbokwe K, and Li J (2005) Community-Based Integrated Water- shed Management. Chinese Journal of Population, Resources and Environment. Vol. 3, No.1.
[14] Mahandule (1991), krishikosh.egranth.ac.in/bitstream/1/5810021914/1/T-

80116.pdf, Gujarat: Shiyani (2002), https://www.researchgate.net/.../292998250_Socio-economic_impact_of_ watershed_dev.
[15] Murthy (1998) in Check Dam Construction by Prioritization of Micro Watershed, using Morphometric Analysis as a Perspective of Remote Sensing and GIS for Simlapal Block, Bankura, W.B V.S.S. Kiran and Y.K. Srivastava, Bonfring International Journal of Industrial Engineering and Management Science, Vol. 2, Special Issue 1.
[16] Palanisami, K., D.Suresh Kumar, (2009) Impact of watershed programme: Experiences and Evidences from Tamilnadu, Agricultural Economics Research Review, Volume.22 pp. 387-396.
[17] Patil R.B., (2017) Watershed develop-ment and management in drought prone area: A case study of Jathtahasil, Maharastra, Research front.
[18] Praveen Raj saxena (2008) Integrated land and water resources conservation and management-development plan using remote sensing and gis of chevella sub-watershed, r.r.distict, andhra pradesh, india, the international archives of the photogrammetry, remote sensing and spatial information sciences. Vol. xxxvii. part b8. beijing.
[19] Ramesh P and Sankara Pitchaiah P (2017), Hydrogeomorphology of Chevella Basin, Ranga Reddy District, Telangana State, International Journal of Engineering Sciences, & Management, ISSN - 2277-5528,Vol. -7, Issue. 1, pp.
[20] RUFFINO, L. (2009) Rainwater Harve-sting and Artificial Recharge to Groundwater. Brussels: SAI Platform.
[21] Satpathi, D. and Bhoj, B.B. (1989) "In Orissa Poverty Takes a Back Seat in Phulbani Districts". Indian Farming, Vol. 34, No.9, Dec., pp. 57-59.
[22] Shingi and Asopa, (2002) www.asa india.org/.../Impact% 20assessment%20of%20Check% 20dams%20in%20the%.
[23] Shivasharanappa and Padaki Srinivas, (2013). Studies on seasonal variations of groundwater qulity using multivariate analysis for Bidar urban and its industries area (Karnataka State- India), International Journal of Research in Engineering and Technoloty, ICRICE conference.
[24] Slusi.dacnet.nic.in, web site of Soil and Land Use SurveyofIndia, Department of Agriculture and Cooperation, Ministry of Agriculture, Govt. of India.
[25] Souvik Ghosh (2004) https://www.researchgate.net/profile/Souvik_Ghosh2
[26] Sreedevi. T.K., Wani S.P., Sudi Raghavendra Rao, Harsha Vardhan Deshmukhi, Singh. S.N., Marcella Dsouza, (2008). Impact of Watershed Development in Low Rainfall Region of Maharashtra: A Case Study of Shekta Watershed. Global Theme on Agroecosystems Report no. xx Patancheru 502 324, Andhra Pradesh, India; International Crops Research Institute for Semi-Arid Tropics.
[27] Srivastava, Asuthosh, S.K.Gupta (1991),"ImpactofWatershed Programme in Mandsaur district of Madhya Pradesh", Indian Journal of Agricultural Economics.Vol.46(3).
[28] Suraj Bhan (2013)Conservation agriculture in India – Problems, prospects and policy issues, International Soil and Water Conservation Research, Volume 2, Issue 4, pp. 1-12.
[29] Thorat MM (2017) A watershed management provides a natural environmental unit for planning a development initiative Int.Res.J. of Science & Engineering,Vol. 5 (5) pp. 81-83.
[30] Wani. S.P., Ramakrishna. Y.S., Sreedevi. T.K., Long. T.D., ThawilkalWangkahart, Shiferaw B, Pathak, P., Keshava Rao A.V.R., (2006). Issues, Concept, Approaches Practices in the Integrated Watershed Management: Experience and lessons from Asia. In: Integrated Management of Watershed for Agricultural Diversification and Sustainable Livelihoods in Eastern and Central Africa: Lessons and Experiences from Semi-Arid South Asia. Proceedings of the International Workshop held during 6-7 December 2004 at Nairobi, Kenya, pp17-36.