Technical Bulletin

Impact Assessment of Integrated Watershed Development in Lachaputtraghati Watershed, Koraput, Odisha

CENTRAL SOIL & WATER CONSERVATION RESEARCH & TRAINING INSTITUTE

(Indian Council of Agricultural Research)

Research Centre, PB.No-12, Sunabeda-763 002, Koraput, Odisha

2014

Technical Bulletin

भा.कृ.अनु.प.
I.C.A.R.

Impact Assessment of Integrated Watershed Development in Lachaputtraghati Watershed, Koraput, Odisha

- M Madhu
- B S Naik
- Praveen Jakhar
- H C Hombegowda
- P P Adhikary
- K P Gore

Central Soil & Water Conservation Research & Training Institute
(Indian Council of Agricultural Research)
Research Centre, PB.No-12, Sunabeda-763 002,
Koraput, Odisha

2014

Citation:

Madhu, M., Naik, B.S., Praveen Jakhar, Hombegowda, H.C., Adhikary, P.P. and Gore, K.P. 2014. Impact Assessment of Integrated Watershed Development in Lachaputtraghati Watershed, Koraput, Odisha. **Technical Bulletein 49p.**

Year of Publication:

2014

Published by:

Central Soil & Water Conservation Research & Training Institute,
(Indian Council of Agricultural Research)
218, Kaulagarh Road, Dehradun -248 195, Uttrakhand, India

Printed at:

Allied Printers
84, Nehar Wali Gali,
Dehradun.
Tel.: 0135-2654505

डॉ. अलोक कुमार सिक्का

उप महानिदेशक (प्रा सं प्र)

Dr Alok K. Sikka

Deputy Director General (NRM)

भारतीय कृषि अनुसंधान परिषद

कृषि अनुसंधान भवन–II, पूसा, नई दिल्ली–110 012

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

KRISHI ANUSANDHAN BHAVAN-II,

PUSA, NEW DELHI-110 012

Phone: 011-25848364 (O), 24121571(R)

Fax : 011-25848366

E-mail: aksikka@icar.org.in; aloksikka@yahoo.co.in

FOREWORD

Holistic development of the rainfed areas is one of the prime concerns of the Government of India. Rainfed areas currently constitute above 57 % of the net sown area of the country, and are home to two-thirds of livestock and 40 % of human population in the Eastern Region of India comprising the states of Bihar, Jharkhand, Eastern UP, Chhattishgarh, Odisha, and West Bengal, which are characterized by low productivity, low income and low employment with high incidence of poverty. The region has a predominance of tribal community constituting about 17% of the total population of the Eastern region.

Watershed management is one of the most trusted and eco-friendly approaches to manage rain water and other natural resources. This has paid rich dividends in the rainfed areas and is capable of addressing many natural, social and environmental concerns. Management of natural resources at the catchment/watershed scale produce multiple benefits in terms of increasing food production, improving livelihoods, protecting environment, addressing gender and equity issues along with biodiversity conservation.

The challenge before the Indian agriculture is to transform rainfed farming into more sustainable and productive systems through integrated resource management following the concept of participatory integrated watershed management. The Government of India has initiated an action plan for extending green revolution to the Eastern Region of the country. With very limited scope of expanding the irrigated area in the country, transforming rainfed farming into more productive system through efficient use of natural resources a way forward.

A multi-disciplinary team of scientists of the CSWCRTI, Research Centre, Sunabeda, Koraput has made commendable efforts in developing the Lachha-Putraghati watershed in the backward tribal belt of Koraput district in Odisha state. I congratulate the entire team of scientists, technical and other staff for the successful development of the watershed in tribal dominated region of the Country.

October 30, 2013
New Delhi

(Alok K. Sikka)

डॉ. प्रशांत कुमार मिश्रा
निदेशक
Dr P.K. Mishra
Director

केंद्रीय मृदा एवं जल संरक्षण अनुसंधान और प्रशिक्षण संस्थान
218, कोलागढ़ रोड, देहरादून–248 195 (उत्तराखण्ड)
Central Soil & water Conservation Research and Training Institute
218, Kaulagarh Road, Dehradun 248 195 (Uttarakhand)
Tel. (O) 0135-2758564, (Res) 0135-2754968,
Fax: 0135-2754213 & 2755386
Email: director@cswcrtiddn.org; directorsoilcons@gmail.com; pkmbellary@rediffmail.com

PREFACE

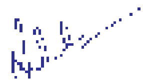
Continued degradation of natural resources is threatening environmental sustainability and livelihood security of millions of people in the country. Land degradation due to soil erosion, resulting in low agricultural productivity, causes socio- economic problems and diminishes the natural resource base. The Eastern region of India, which accounts for 17% of total geographical area of the country, is bestowed with abundant natural resources. It supports (24%) human population (290.8 M) and 20% tribal population of the country. About 69% of the net cultivated area is rainfed and it depends on the vagaries of monsoon. About 32.43% area in Eastern region has potential erosion rate of more than permissible limit and 62.53% of total geographical area of the region is degraded exclusively by water induced soil erosion.

The Government of India has launched various programmes/schemes to increase productivity and livelihood security in the region through rehabilitation of degraded lands following the approach of watershed management. It has been an effective tool for rural transformation with an emphasis on community based natural resource management through social and technical processes in a multi-stakeholder partnership with villagers, development agencies and planners. Benefits of resource conservation and management through participatory watershed approach have substantially improved productivity, moderated floods, mitigated droughts, augmented ground water recharge, generated on farm employment and improved socio-economic conditions of stakeholders. The Central Soil and Water Conservation Research and Training Institute (CSWCRTI) is a premier Institute under ICAR and has a rich experience in dealing with and developing strategies for land degradation problems in the country. To cater the problems of soil erosion and land degradation, the Institute operates through its eight Research Centres located in different parts of the country. In the Eastern region, the CSWCRTI Research Centre, Koraput has been looking after the problems of soil erosion and land degradation due to shifting cultivation.

Keeping in view the problems of the region, 'Lachhaputraghati' (LPG) watershed project was undertaken near Damanjodi in backward tribal dominant Koraput District of Odisha during 2008-2013 with the sponsorship of Ministry of Agriculture, Govt. of India under Micro-Management of Agriculture (MMA), National Watershed Development Project for Rainfed

Areas (NWDPRA) scheme. Koraput district is one among the top one- third districts identified by the NRAA (2012) based on high Rainfed Areas Prioritization Index (RAPI). The project was a concerted effort to render basic livelihood amenities, empower and organize the tribal community into viable and resilient groups, infuse/refine skills to build capacities and self reliance, and integrate conservation and production technologies for sustainable land and water resources. A blend of the Centre's recommended technologies and local level innovations was attempted under the project.This report of LPG watershed project presents a comprehensive assessment of the bio-physical and socio-economic impacts of various interventions in the watershed for augmenting socio-economic/livelihood security in tribal dominated rainfed areas. It is expected that this publication will be very helpful for various watershed functionaries and others who are working for rehabilitation of degraded land and tribal development in the region. I congratulate the staff of Koraput Centre for bringing out this important publication on time.

December 5, 2013
Dehradun



(P.K. Mishra)

ACKNOWLEDGEMENT

The project study team of Central Soil & Water Conservation Research &Training Institute (CSWCRTI), Research Centre, Koraput express their sincere gratitude to Dr S. Ayyappan, Secretary, DARE and DG, ICAR, Dr A.K. Singh, former DDG (NRM) and Dr A.K. Sikka, DDG (NRM), ICAR, New Delhi for their encouragement, motivation and support during the project period. The team is indebted to Dr V.N. Sharda, Member, Agriculture Scientist Recruitment Board (ASRB), New Delhi and Former Director, CSWCRTI, Dehradun for initiating this project, arranging funding and providing guidance in successful implementation and monitoring of the project. We are very much thankful to Dr P.K. Mishra, Director, CSWCRTI, Dehradun for his guidance, encouragement and support for bringing out this technical bulletin.

Authors are highly thankful to Er. C.P. Arora, former OIC, Dr B.L. Dhyani, OIC and Shri Nirmal Kumar, Technical Officer of the PME Cell for timely processing of project proposals, all support during the study period and in bringing out this publication.

We are very much thankful to Dr G.P. Reddy, former Director, OWDM, Govt. of Odisha, Shri G. Parida and Shri R.P. Patil, Ex. Collectors of Koraput District for their valuable local support for execution of the project in remote tribal area of Koraput district. The timely co-operation of SCO, Koraput, DRDA, Koraput, BDO, Koraput, Officers of line Departments, Govt. of Odisha and NGOs are gratefully acknowledged.

The association and contributions of Dr R.K. Panda, former Senior Scientist (SWC Engg) and Dr D. Barman, Scientist (Soils) to this project is duly acknowledged.

Authors highly appreciate the technical assistance rendered by Sri G.B. Naik, Shri B. Chandran, Shri B.K. Dash, Shri G.W. Barla, Shri S. Kindal and Shri D. Jena for carrying out the project works. The administrative support extended by Smt H. Lakra and Smt. A. Nayak is duly acknowledged. A special appreciation and thanks to Shri R.S. Prasad for providing administrative support and systematic maintenance of accounts.

We are also thankful to Dr D.C. Sahoo, Senior Scientist (Engg.) CSWCRTI, Research Centre, Koraput for his help during preparation of this report.

The President of LPG Watershed Association, Watershed Committee Chairman and Members, Watershed Secretary, Volunteers and all the members of the watershed villages deserve special thanks for their active involvement and cooperation, without which it would not have been possible to carry out this project.

Authors are highly thankful to the Ministry of Agriculture, Govt. of India for funding this project under Micro Management of Agriculture (MMA), NWDPRA.

The study team would like to express their gratitude to the Chief Administrative Officer, Senior Finance and Accounts Officer and their staff at the Institute Headquarter for their support during the project period and publishing this bulletin.

Authors

CONTENT

LIST OF TABLE

LIST OF FIGURES

LIST OF PHOTOS

SUMMARY OF IMPACT ANALYSIS

A. Details About the Watershed			
About the Watershed		**Resources & Demographic Features**	
Watershed	Lachha-Putraghati	LCC	III (43.1%), VI (22.6%) & VII (20%)
Teshil	Pottangi	Vegetation	Tropical scrub forest
District	Koraput	Land use	Degraded forest (61%), Net cultivated area (20.15%), Current fallow (11.5%)
State	Odisha	Total HH	315
AER	12	Population	992
Area (ha)	601.24	Tribal	661(66%)
Av. Slope (%)	12	Land less	84(27%)
Order	4th	Major tribes & SC	*Kandha, Paroja* and SC is *Domb*
Av. Rainfall (mm)	1452	Occupation	Agriculture (62%)
LGP (Days)	170	Av. land holding (ha)	0.52

II. Biophysical Impact Indicators					
S.No	**Indicators**	**Unit**	**Before (2008)**	**After (2012-13)**	**Change**
1	**Potential Soil Erosion Rate**				
i	Arable	$t\ ha^{-1}\ yr^{-1}$	17.93	15.61	↓ 12.90%
ii	Non- Arable	$t\ ha^{-1}\ yr^{-1}$	37.23	30.38	↓ 18.40%
iii	WS Average	$t\ ha^{-1}\ yr^{-1}$	30.24	25.03	↓ 17.20%
iv	Soil retention capacity of trenches	$t\ ha^{-1}$	13.69		
2	**Estimated Runoff**	%	14.68 to 29.92	7.3 to 15.4	
i	Av.runoff	%	24.4	14.6	↓ 40%
3	**Water Resources Development**				
i	Storage capacity created	ha-cm	93.91		

S.No	Indicators	Unit	Before (2008)	After (2012-13)	Change
ii	Additional area under irrigation	ha	24.2		
iii	Av. water table depth	m	2.97	2.8	5.90%
iv	Av. depth of water in well	m	0.99	1.17	17.80%
4	**Productivity Indicators**				
i	Productivity of crops	%	9.14		
ii	Crop diversification index		0.55	0.71	30%
iii	Cultivated land utilization index		0.35	0.4	14.3%
iv	Crop productivity index		0.55	0.61	12%
v	Crop fertilization index		0.21	0.3	43%
vi	Watershed productivity (REY)	kg ha^{-1}	4962	6126	19%
vii	Induced watershed eco-index			0.04	4%
5	**Dry land Horticulture**				
i	Av. survival rate	%	68		
ii	BCR at 15% DR		2.75		
iii	IRR	%	21.28		
iv	Density of trees in agriculture land	trees ha^{-1}	7	14	7
6	**RWUE, EERW & Returns per m^{-3} of Rain Water**				
	Crops	**RWUE (kg ha^{-1} mm^{-1})**	**EERW (MJ m^{-3})**	**Returns (₹m^{-3})**	
i	Av. Cereals	2.34	5.3	4.3	
ii	Av. Pulses	1.70	3.8	10.7	
iii	Av. Oil seeds	1.26	3.0	4.7	
iv	Av. Vegetables	35.33	9.9	38.5	
v	Av. Spices	24.31	4.3	144.0	
vi	Average for all crops	14.72	35.0	5.5	
7	**Carbon Sequestration Potential**	**Years**	**10**	**20**	
i	C	t ha^{-1} yr^{-1}	2.12	3.40	
ii	C Credit	₹ ha^{-1} yr^{-1}	2544	4080	
8	**Human Population Carrying Capacity**	**Unit**	**Before (2008)**	**After (2012-13)**	**Change**
i	Av. Energy output	MJ ha^{-1}	18296	20006	9.30%
ii	Av. HPCC of land	Adult ha^{-1}	4	4.4	9.30%
iii	Jhola land	Adult ha^{-1}	6.6	7.2	8.50%
iv	Beda land	Adult ha^{-1}	4.2	4.6	9.70%
v	Padda & Donger land	Adult ha^{-1}	2.7	3	8.50%

III. Socioeconomic Impact Indicators

S.No	Indicators	Unit	Before (2008)	After (2012-13)	Change
1	**Overall People's Participation Index (%)**		56		
2	**Av. Family Income**	(₹ yr^{-1})			
i	Large		35700	41000	↑ 5300
ii	Medium		21854	31700	9846
iii	Small		13750	18770	5020
3	**Av. Family Expenditure**	(₹ yr^{-1})			
i	Large		28500	34000	↑ 5500
ii	Medium		18600	27500	8900
iii	Small		13500	18300	4800
4	**Employment Generation**	Man days	14052		
5	**IGAs (Annual income per SHG)**	₹14, 000/- to ₹.40, 000/- (₹900 per head)			
6	**Amount in WDF Account**	₹	121252/-		
7	**The Economic Viability of the Project**	at 10% DR			
i	BCR		1.16		
ii	IRR (%)		19.5		

8	**Technical Man Days at Different Phases of Watershed Development (per ha)**				
	Area	Preparatory	Watershed Work	Consolidation	Total
i	Total WS area (601 ha)	0.38	2.26	0.55	3.20
ii	Treatable area (451 ha)	0.51	3.02	0.74	4.26

कार्यकारी सारांश

देश की कुल बुवाई क्षेत्र का 55 प्रतिशत वर्षा आधारित है और यह क्षेत्र पूर्वी भारत की 40 प्रतिशत जनसंख्या एवं दो तिहाई पशुधन को समाए है। यह क्षेत्र आदिवासी बहुल है जो कुल जनसंख्या का 30 प्रतिशत (37.9 मिलियन) है। इस क्षेत्र में 54 आदिवासी समुदाय पाये जाते हैं। पूर्वी क्षेत्र का कुल भौगोलिक क्षेत्रफल का 62.5 प्रतिशत केवल पानी के कटाव एवं मृदा क्षरण से ग्रसित है। मृदा लवणता एवं अम्लीय मृदा का क्षेत्रफल मिलाकर यह आंकड़ा 73.9 प्रतिशत तक पहुँचता है। मृदा क्षरण सहनशीलता की सीमा का सीमामूल्य (T) पर यह 7.5 से 12.5 टन प्रति हैक्टेयर प्रति वर्ष तक का संकेत देता है। अन्धाधुंध वनों की कटाई और झूम (स्थानान्तरित) खेती के कारण मृदा का अत्याधिक क्षरण इस क्षेत्र में पाया जाता है तथापि ढालू जमीनों पर मृदा संस्थापन करने की आवश्यकता हैं। भारत सरकार ने वर्ष 2003 के बाद जलागम प्रबंधन को एक राष्ट्रीय नीति के रूप में अपनाया है और गत 3 दशकों में वर्षा आधारित क्षेत्रों में स्थाई कृषि उत्पादकता को विभिन्न राष्ट्रीय कार्यक्रमों से कार्यान्वित किया हैं। पूर्वी क्षेत्र में कार्यान्वित प्रमुख राष्ट्रीय कार्यक्रमों में NWDPRA, IWDP, RVP, WDPSCA, NAP, DPAP इत्यादि प्रमुख है। वर्ष 1990 से आरंभ करके देश में बड़े पैमाने पर जलागम विकास कार्यक्रमों में भागीदारी जल प्रबंधन का दृष्टिकोण अपनाकर विभिन्न क्षेत्रों में कृषि विकास के कार्य किये। ऐसा ही एक कार्यक्रम उड़ीसा के आदिवासी बहुल क्षेत्र में कृषि मंत्रालय, भारत सरकार, नई दिल्ली द्वारा प्रायोजित किया गया। NWPDRA के मेकरो प्रबंधन के तहत 2008 में केन्द्रीय मृदा एवं जल संरक्षण अनुसंधान एवं प्रशिक्षण संस्थान, अनुसंधान केन्द्र, सुनाबीडा, कोरापुट द्वारा लागू किया गया। राष्ट्रीय वर्षा क्षेत्र प्राधिकरण, नई दिल्ली के अनुसार यह जिला रेनफेड एरिया प्रायोटाईजेशन इनडेक्स पर 110वें स्थान पर है। लछापुत्रघाटी जलागम का व्यापक मूल्यांकन इसमें किये गये जैविक, भौतिक और सामाजिक कार्यों के प्रभावों का आंकलन करने के लिए किया गया। इस कार्यक्रम का मुख्य लक्ष्य उन प्रमुख घटकों की पहचान है, जिनका प्रभाव जनजातियों के प्रगति एवं आर्थिक व्यवहारता पर सबसे अधिक पड़ता है। वाटरशेड विकास गतिविधियों में मृदा एवं जल संरक्षण, जल संस्थान विकास, मृदा उत्पादकता वृद्धि गतिविधियां, आय स्रजन गतिविधियां, सामुदायिक संगठनात्मकता एवं क्षमता निर्माण हैं। प्रमुख प्रभाव कारकों का संक्षिप्त ब्यौरा इस प्रकार हैः

1. संभावित मुदा क्षरण दरः वाटरशेड में संभावित मृदा कटाव परियोजना पूर्व (2008) एवं परियोजन के बाद (2012) के लिए अनुमानित किया गया। परियोजना पूर्व वानस्पतिक आछादन के अभाव में परियोजना पूर्व अधिक से अधिक क्षेत्र कटाव कक्षा (> 40 टन प्रति हैक्टेयर प्रति वर्ष) में था। परियोजना अवधि पश्चात् उच्च कटाव वर्गों के प्रतिशत क्षेत्र मे कमी आई और यह बहुत कम और मध्यम कम कक्षा की ओर स्थानान्तिरत हो गये। यह कमी मेड़बन्दी, खाईयो का निर्माण और विभिन्न संरक्षण उपायों के कारण ही संभव हुआ। औसत मृदा क्षरण दर परियोजना पूर्व एवं पश्चात् क्रमशः 30.24 एवं 25.03 टन प्रति हैक्टेयर प्रति वर्ष पाई गई।

2. अपवाहः विभिन्न भूमिउपयोग क्षेत्रों में अनुमनित अपवाह 14.68 से 29.92 प्रतिशत एवं 7.3 प्रतिशत से 15.4 प्रतिशत क्रमशः परियोजना पूर्व (2008) तथा पश्चात् (2012) अनुमानित किया गया। अधिकतम अपवाह परियोजना पूर्व अवधि के दौरान रागी और उपरी जमीन धान में 29.92 प्रतिशत था जो, परियोजना पश्चात् घटकर 15.4 प्रतिशत हो गया। जल अपवाह में औसतन कमी 24.4 से घटकर 14.6 हो गई।

3. जल संसाधन विकासः जलागम क्षेत्र में वर्षा जल संग्रहण और इसकी उपलब्धता बढ़ाने के लिए विभिन्न उपाय किये गये, जिसमें डोंगी तालाब, बड़े तालाब, जलकुण्डी और छोटे बाँधों का निर्माण उल्लेखनीय है। लगभग 93.91 हैक्टेयर सेन्टीमीटर वर्षा जल भण्डारण क्षमता का निर्माण हुआ, जिसके फलस्वरूप 24.2 हैक्टेयर अतिरिक्त क्षेत्र चावल एवं सब्जियों की खेती के अधीन लाया गया। इस से 177 किसान रक्षात्मक सिंचाई के अन्तर्गत लाभार्थी बने।

4. भूमि जल स्तरः औसतन भूमि जल स्तर 0.18 (59 प्रतिशत) मीटर बढ़ा और कुँओं में यह आँकड़ा 17.8 प्रतिशत था। यह तुलनात्मक अध्ययन वाटरशेड अवधि पूर्व एवं पश्चात् का हैं। भूमि जल स्तर का उठाव मानसून पश्चात अधिर प्रखर था। इसका श्रेय जलग्रहण क्षेत्र में मृदा एवं जल संरक्षण के उपायों को दिया जाना चाहिए।

5. फसल विविधीकरण एवं उत्पादकताः परियोजना अवधि के दौरान अनाजों, दालों, तिलहन फसलों का कुल क्षेत्र 45.4 हैक्टेयर तक बढ़ा इसी तरह 24 हैक्टेयर अतिरिक्त क्षेत्र की वृद्धि बागवानी सब्जियों में हुई। एकत्रित पैदावार आँकड़ो के आधार पर औसतन 3 से 15 प्रतिशत की पैदावार बढ़ोतरी हुए और 9.14 की कुल औसत वृद्धि हुई।

6. खेती की जमीन का उपयोग सूचकांकः CLUI की गणना प्रत्येक फसल के लिए लगाये गए भूमि के उत्पादों गुणा कुल खेती की भूमि क्षेत्र को 365 दिनों से विभाजित किया। यह सूचकांक शुष्क भूमि में बागवानी वृक्षारोपण को बड़े पैमाने पर लागू करने और सिंचित क्षेत्र के तहत वृद्धि परिणामस्वरूप 0. 05 से 0.35–0.40 तक बढ़ा। यह दर्शाता है कि सिंचित क्षेत्र में गहन फसल उत्पादन हुआ। यह स्पष्ट रूप से दर्शाता है कि परियोजना में किये गये कार्य सफल रूप से परिलक्षित हुए।

7. फसल उत्पादकता सूचकांकः यह सूचकांक सामान्य उपज की तुलना में फसल उत्पादकता स्तर को इंगित करता है। यह जलागम में हो रहे फसल उत्पादकता स्तर में परिवर्तन का मूल्यांकन करने के लिए आंका गया। कुल मिलाकर यह सूचकांक 0.547 (परियोजना पूर्व 2008) से 0.613 (परियोजना बाद 2012) 12 प्रतिशत की दर से बढ़ा। इसका श्रेय उत्तम बीजों का प्रयोग और पोषक तत्वों का संतुलित उपयोग को दिया जाना चाहिए।

8. फसल निषेचन सूचकांकः यह सूचकांक फसलों के लिए पोषक तत्वों की सिफारिश स्तर की तुलना में लागू फसल पोषक तत्वों (NPK) की सीमा को इंगित करता है। कुल मिलाकर यह (CFI) 0.21 से बढ़कर परियोजना पश्चात् 0.30 तक 43 प्रतिशत वृद्धि दर्ज कराई। यह सब्जी उत्पादन में पोषक तत्वों के प्रयोग एवम् उनके अच्छे बाजार मूल्य से हुआ। परियोजना कार्यकलापों में अच्छे बीजों और पोषकतत्वों का वितरण भी किया गया। परन्तु CFI जलग्रहण क्षेत्र में अभी भी कम है, इसका मूल कारण (NPK) खपत फसलों के लिए पोषक तत्वों की खुराक की तुलना में आधे से भी कम उपयोग है।

9. जलागम उत्पादकताः यह जलग्रहण क्षेत्र की समग्र उत्पादकता स्तर को दर्शाता हैं इसका आंकलन फसलों के उत्पादन, उत्पादन क्षेत्र और उत्पादन मूल्य को लेकर मुख्य फसल के बराबर पैदावार में व्यक्त की गई है। जलागम क्षेत्र की उत्पादकता विभिन्न फसलों के उत्पादन को रागी के बराबर उत्पादकता में व्यक्त किया गया है। यह आंकड़ा परियोजना पूर्व की स्थिति 4962 किलोग्राम प्रति हैक्टेयर था और परियोजना बाद में 6126 तक बढ़ा। यह मुख्यतः सिंचित क्षेत्र में वृद्धि एवं फसल उत्पादन में वृद्धि, फसलों के विविधिकरण से संभव हुआ। जलागम उत्पादकता का 19 प्रतिशत बढ़ाव मुख्यतः सब्जी की खेती के तहत बढ़ते हुए क्षेत्र से हुआ, जो किसी भी अनाज वाली फसलों की तुलना में अधिक है।

10. कार्बन जब्ती क्षमताः कुल कार्बन जब्ती क्षमता का आंकलन जलागम में किये गये वृक्षारोपण की मौजूदा जीवनदर और औसत विकास दर को ध्यान में रखते हुए, 10 और 20 साल की अवधि के बाद अनुमानित किया। सर्वाधिक कार्बन जब्ती क्षमता, ऊर्जा वृक्षारोपण तत्पश्चात् जैव डीजल और कृषि बागवानी वृक्षारोपण से हैं। कुल 391.24 टन एवम् 1114.65 टन कार्बन जब्ती क्षमता का आंकलन क्रमशः 10 और 20 साल के लिए किया गया है। औसतन यह क्षमता 2.12 और 3.4 टन प्रति हैक्टेयर जलग्रहण के वृक्षारोपित क्षेत्र से 10 और 20 साल बाद अनुमानित हैं। इसका मूल्यांकन अगर अमरीकी डॉलर 20 टन प्रति युनिट कार्बन पर किया जाए तो यह 10 और 20 वर्ष के लिए क्रमशः 42.8 अमरीकी डॉलर (2544 रूपए) और 68 (4088 रूपए) प्रति हैक्टेयर प्रति वर्ष होता है। (1 अमरीकी डॉलर – 60 रूपए)

11. मानव आबादी क्षमताः यह एक व्यस्क की वार्षिक ऊर्जा जरूरतों के लिए भूमि के उपयोग या उत्पादन प्रणाली से ऊर्जा उत्पादन का अनुपात हैं। ऊर्जा प्रत्येक भूमि के उपयोग से उत्पादन या फसलों की ऊर्जा गुणांक मूल्यों के आधार पर की गई है, वार्षिक ऊर्जा आवश्यकता राष्ट्रीय पोषकता संस्थान, हैदराबाद की सिफारिशों के आधार पर गणना की गई है। HPCC अलसी में सबसे कम (1) और आलू में अधिकतम (12.2) पायी गई। अनाज फसलों में झोला जमीन में धान, उपरी जमीन धान और मक्का में 4.9 – 6.6 परियोजना पूर्व (2008) एवम् 5.5 – 7.2 परियोजना पश्चात् (भार) अंकति की गई। औसतन HPCC 4.0 – 4.4 तक बढ़ी और 9 प्रतिशत की वृद्धि को दर्ज कराया।

12. जनभागीदारीः जल प्रबंधन परियोजना में लोगों की भागीदारी इसकी स्थिरता का एक महत्वपूर्ण सूचकांक है। इसका आंकलन PPI के द्वारा किया गया, जिसमें वाटरशेड के प्रारम्भिक चरण, कार्यचरण और समेकन चरण में की गई लोगों की भागीदारी को ध्यान में रखते हुए किया। समग्र PPI का 56 प्रतिशत सूचकांक लोगों की भागीदारी को मध्यम स्तर से ऊपर को दर्शाता है अगर इसको विभिन्न चरणों में बाँटे तो; जनता की सबसे अधिक भागीदारी 64 प्रतिशत प्रारम्भिक चरण में थी जो घटकर 58 प्रतिशत कार्यचरण में हूई और अन्ततः यह समेकन चरण में 46 प्रतिशत हुई। लोगों की भागीदारी का यह उच्च स्तर जलागम पदाधिकारियो के ईमानदारी से प्रतिबद्ध और समर्पित प्रयासों से संभव हुआ। इसके अलावा वाटरशेड प्रबंधन में PIA की विशिष्ट योग्यता को भी दिया जाना चाहिए। लोगों की सक्रिय भागीदारी वाटरशेड कार्यक्रम की सफलता में अत्याधिक महत्वपूर्ण है, सभी हितधारकों की सक्रिय और स्वैछिक भागीदारी वाटरशेड के सफल कार्यान्वन की गारंटी है।

13. आय एवं व्यय में बदलावः आय व्यय का विशलेषण जलागम लाभार्थियों के विकास में एक महत्वपूर्ण गतिविधि है। यह विशलेषण परियोजना के क्रियान्वन के पूर्व (2008) एवं पश्चात् में किया गया। यह विश्लेषण किसानों के विभिन्न समूहों जैसे बड़े, छोटे, मझोले के नमूनो के आधार पर किया। इस विश्लेषण से यह ज्ञात हुआ कि, बड़े किसान के आय का स्त्रोत कृषि के साथ–साथ पशुपालन एवम् रोजगार भी है। परियोजना पश्चात् आय का गैर–संसाधन वित्त की बजाय कृषि गतिविधियों पर आना (5 प्रतिशत) एक अच्छा बदलाव है। परियोजना में सभी श्रेणी के किसानों की आय सर्जन गतिविधियों एवं क्षमता निर्माण में प्रयास किये गये है। छोटे किसानों का कृषि गतिविधियों में बढ़ता खर्च उनके पलायन को रोकने और लाभ खेती करने को आकर्षित करती है।

14. आजिविका विकास के लिए गतिविधियों का सर्जनः जलग्रहण क्षेत्र की काफी आबादी (27 प्रतिशत), जो 84 परिवारों की है, भूमिहीन है। इस जनसंख्या के लिए मौसमी एवम् वर्षपर्यान्त आय स्रजनात्मक गतिविधियां जरूरी है। कुल मिलाकर 221 भूमिहीन किसान, महिलाएं और बेरोजगार युवक इन गतिविधियों से लाभान्वित हुए। प्रत्येक स्वयं सहायता समूह को वार्षिक सकल आय रूपए 14000 से रूपए 40,000 तक अर्जित हुई। औसतन प्रति लाभार्थी वार्षिक सकल आय 900 रूपए है।

15. सामुदायिक अंशदानः वाटरशेड कार्यों के प्रति समुदाय की भागीदारी को एक योगदान के रूप में माना जाता है। इसके अलावा नगदी योगदान वाटरशेड के प्रति जिम्मेदारी के भाव को दर्शाता है। इस परियोजना के तहत बनाए गये कार्यों और गतिविधियों को बनाए रखने की प्रतिबद्धता को भी दर्शाता हैं। लोगों द्वारा विभिन्न गतिविधियों में बढ़–चढ़ कर भाग लेने और पंचायती भूमि में निजी योगदान के लिए आना एक अच्छा संकेत है। जल प्रबंधन के विभिन्न कार्यों के तहत 1,21,252 रूपए की कुल राशि योगदान के रूप में प्राप्त हुई, जो परियोजना पश्चात् रख–रखाव के लिए काम ली जाएगी।

16. परियोजना की आर्थिक व्यवहारताः परियोजना का आर्थिक विशलेषण विभिन्न गतिविधियों में कृषि और गैर–कृषि योग्य भूमि पर किये हुए कार्यो में लागत और प्रत्यक्ष लाभ पर विचार करके किया। जलागम परियोजना के उत्पादक जीवन को 20 साल मान लिया गया। लाभ लागत अनुपात 10 प्रतिशत अनुदान दर पर 1:1.6 पाया गया एवं कृषि योग्य भूमि के लिए IRR 19.5 प्रतिशत पाई गई। यह परियोजना की आर्थिक व्यवहारता को दर्शाता है।

सिफारिशें

1. आदिवासी समुदाय के सांस्कृतिक सामाजिक अर्थशास्त्र को पूरी तरह से समझने की जरूरत है और किसी भी परियोजना के सफल क्रियान्वन के लिए सामुदायिक भागीदारी और समर्थन बहुत जरूरी है।

2. अधिकांश आदिवासी गाँव में अभी भी मूलभूत सुविधाओं की कमी है, इस अन्तराल को भरने के लिए बुनियादी ढांचे के विकास को सम्बोधित करना अति आवश्यक है।

3. झोला जमीन जल की एक बारहमासी धारा हैं, इसके दोनो तरफ अधिकतम खेती का क्षेत्र है। जल ग्रहण क्षेत्रों में मृदा और जल संरक्षण के उपायों में वनस्पति आछांदन करना अतिआवश्यक हैं, जिससे यह धारा निरंतर प्रवाहित होती रहे।

4. उड़ीसा के पूर्वी घाट क्षेत्रों में झोला जमीन का वर्गीकरण, उनका उपयोग प्रणाली एवम् विकास का आंकलन करने की जरूरत है।

5. बेडा जमीन, झोला जमीन के ऊपर मध्यम ढलान की जमीन है जो उच्च मूल्य की फसलें जैसे सब्जी, मक्का इत्यादि के लिए उपयुक्त है। इस जमीन पर छोटे पैमाने पर सिंचाई प्रणाली, डोंगी तालाबों आदि के माध्यम से जल संसाधन की विकास करके फसल उत्पादकता (गहनता) बढ़ाने की आवश्यकता है।

6. निम्नीकृत जंगल, मृदा, जल संरक्षण और जल संचयन के साथ कृषिवानिकी प्रणाली की प्रबल संभावनायें है। इन क्षेत्रों में वर्षा उपरान्त मौसम के दौरान अनियंत्रित चराई ने वृक्षारोपण की स्थापना के लिए बहुत बड़ा खतरा हैं। इसलिए व्यक्तिगत भूमि जोत में जैव बाढ़ लगाने की लागत जलग्रहण परियोजना के द्वारा देने का सुझाव दिया है।

7. उच्च ढलानों पर विकृत वन भूमि का संरक्षण एवम् विकास, सामुदायिक भागीदारी से करना चाहिए ताकि समुदाय को उचित लाभ मिलें।

8. जनजातीय समुदाय अभी भी विशेष रूप से उच्च मूल्य की फसलों के लिए सूक्ष्म सिंचाई प्रणाली के उपयोग के साथ आश्वस्त नहीं है। वर्षा जल उपयोग दक्षता और उत्पादकता में सुधार लाने के क्रम में इस दिशा में आगे केंद्रित प्रयास आवश्यक है।

9. इस क्षेत्र में भूमि एवं फसल विविधीकरण के प्रभूत विस्तार की संभावनाए हैं। जल ग्रहण परियोजना द्वारा इनसे समर्थित तकनीकों को बहुत उज्जवल भविष्य है।

10. प्रत्येक जिले के जल ग्रहण परियोजना के मूर्त एंव अमूर्त लाभ का आंकलन करने के लिए जल विज्ञान निगरानी आवश्यक है तथा सामाजिक, जैविक एवम् भौतिक लाभ के आंकलन की आवश्यकता है।

1 INTRODUCTION

Background

The burgeoning population demands additional resources to meet the growing needs in terms of food, fodder, fiber, fuel, fruit and water. Each year an additional 0.25 billion metric tons of grain (21% higher) must be produced to feed the increased population (PBIO 100 Lectures Notes, 1999). Globally, 80% of agriculture is rainfed and contributes 60% to world's food basket. Current productivity of rainfed agriculture is low (<1 t ha^{-1}) and to be increased for sustainable agricultural productivity to achieve second green revaluation. Over 120 M ha land area has been declared degraded (Maji, 2007; NRAA, 2011) in India. Holistic development of the rain-fed areas is one of the prime concerns of the Government of India. About 60% of total arable land (142 M ha) in the country are rain-fed, characterized by fragile and marginal land with low productivity, low income, low employment and high incidence of poverty. Development of watershed/catchment is one of the most trusted and eco-friendly approaches to manage rainwater and other natural resources, which has paid rich dividends in the rain-fed areas and is capable of addressing many natural, social and environmental intricacies (Samra, 1998; Wani *et al.*, 2002, 2003a, b; Rockstorm *et al.,* 2007). Management of natural resources at the catchment/watershed scale produce multiple benefits interms of increasing food production, improving livelihoods, protecting environment, addressing gender and equity issues along with biodiversity concerns (Sharma, 2002; Wani *et al.,* 2003a, b; Joshi *et al.,* 2005; Ahluwalia, 2005; Rockstorm *et al.,* 2007) and is also recommended as the best option to upgrade rain-fed agriculture to meet the growing food demand globally (Rockstorm *et al.,* 2007).

Water and soil resources are finite, non-renewable over the human lifetime frame, and prone to degradation through misuse and management (Lal, 2000). Scarcity of water for agricultural and domestic purpose remains a major problem and has led to low crop productivity and environmental degradation. Decline in per capita agricultural production has seriously affected food security and livelihoods of people. There is a considerable potential to bridge the yield gap between the actual and the potential yield through adoption of improved resource management technologies (Singh *et al.,* 2001). Several studies have highlighted that appropriate rainwater management and utilization results in enhanced agricultural productivity (Samra, 1997; Wani *et al.,* 2003a, b; Joshi *et al.,* 2005). The challenge before the Indian agriculture, therefore, is to transform rainfed farming into more sustainable and productive systems through efficient use of natural resources through the integrated resource management following the concept of participatory integrated watershed management.

Rainfed areas currently constitute 63 % of the net sown area in the Eastern Region of India and supporting 20% of livestock and 28% of human population of the country. The region has a predominance of tribal (54 tribal communities) constituting about 30 % of the total population of 37.9 M (Chauhan, 1998). It's also observed that around 62.5% of the total geographical area of Eastern Region is degraded exclusively by water induced soil erosion which in conjunction with salt-affected and acid soils works out to be 73.9%. Data on soil loss tolerance limits indicate that the tolerance (T) value varies between 7.5 and 12.5 t ha^{-1} yr^{-1} across the region. Indiscriminate deforestation and practice of Jhum cultivation lead to accelerated erosion for which proper conservation measures are need to be adopted especially on very steep slopes. The Government of India (GOI) adopted watershed management as a strategy to address the sustainable agricultural productivity in the rain-fed areas for the last three decades. Further, GOI has adopted a watershed management as a national policy since 2003 (Joshi *et al.,* 2004). The prominent national programmes implemented in the Eastern region are NWDPRA, IWDP, RVP/FPRs, WDPSCA, NAP and DPAP. With the launch of massive watershed development programmes in the country during 1990's, all the previous programmes were converged to develop e different areas by adopting a participatory watershed management approach. The maximum area has been treated under IWDP (43.9 lakhs ha) followed by DPAP (25.9 lakh ha), NWDPRA (13.7 lakh ha) and other programmes (13.6 lakhs ha) since inception. Similarly, the maximum expenditure has been made under NAP (₹708.88 crores) followed by NWDPRA (₹547.11 crores) (Sharda *et al.,* 2008 & 2010).

A model watershed in the tribal dominated areas of Odisha was implemented by CSWCRTI, Research Centre, Sunabaeda, Koraput under the MMA, NWDPRA, sponsored by the MoA, GOI, New Delhi. Koraput district (110) is one among the top one-third districts (167) based on high Rainfed Areas Prioritization Index (RAPI) by the NRAA (2012). A comprehensive assessment of LPG watershed was taken up to assess the bio-physical and socioeconomic impacts of various interventions in the watershed. The overall goal of this case study is to get insights into watershed management programs as an implementer and to identify the key components for augmenting the progress and impact on tribes in the rainfed areas.

1.2 Objectives of the Study

- To assess the impact of watershed development activities on land degradation, rainwater availability and its productivity, crop productivity and livelihoods in the tribal dominated micro watershed.
- To assess the socioeconomic impact of the watershed interventions. To identify the gaps/constraints for effective planning and implementation of activities in the watershed for the harnessing full potential of rainfed ecosystems.

2 DESCRIPTION OF THE WATERSHED

2.1 Location

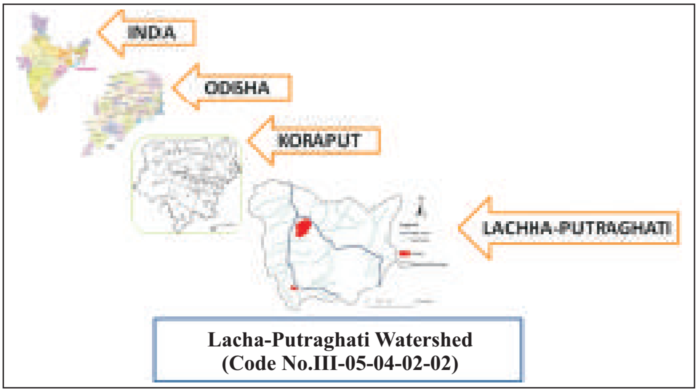


Figure 2.1: Location map of LPG watershed

Lachhaputraghati (LPG) watershed is located in Pottangi Tehsil of Koraput District in Odisha state. The watershed is 20 km from Semiliguda town and 45 km from Koraput District headquarters (Figure 2.1). The watershed consists of three cluster villages namely Lachhumani, Kandaputraghati and Ariputraghati under Litiguda Gram Panchayat (GP). The geographical location is 82° 56’ to 82° 58’ E longitude and 19° 45’ 30’’ to 19° 47’ 30’’ N latitude with an elevation range of 900 m to 1258 m above msl. The total area of the watershed is 601.24 ha with undulating to steeply sloping (up to 50%) topography. The order of the watershed is 4th with a drainage density of 7.14 km km^{-2}. The physiographic detail of the watershed is presented in Table 2.1.

Table 2.1: Physiographic details of the LPG watershed

S.No.	Physiographic detail	
1	Agro-ecological region	12
2	Area (ha)	601.24
3	Elevation range (m amsl)	900-1258
4	Average slope (%)	12
5	Order of the watershed	Fourth
6	Drainage density (km km^{-1})	7.14
7	Form factor	0.67
8	Length of main channel (km)	3.75
9	Perimeter (km)	10.6

2.2 Climate and Water Balance

The climate of the watershed is warm and humid with an annual mean maximum and minimum temperature of 35.8° C and 7.6° C, respectively. The normal annual rainfall is 1452.2 mm received in 77 rainy days (Figure 2.2). About 81% of the total rainfall is received through June to September (South-West monsoon). Bright sunshine hours vary from 1.84 to 3.98 and 6.29 to 9.04 during the monsoon and the post monsoon season, respectively. The average evaporation rate is 3.7 mm day^{-1} with maximum in May (6.2 mm day^{-1}) and minimum during the month of August (2.1 mm day^{-1}). Water balance diagram showed that, surplus water is available for agricultural use between the month of May and October with a length of growing period is about 170 days (Figure 2.3).

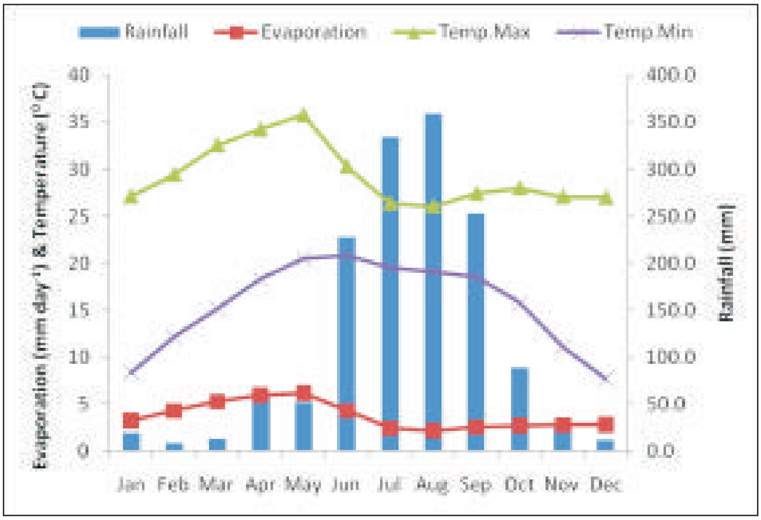


Figure 2.2: Weather parameters at the LPG watershed

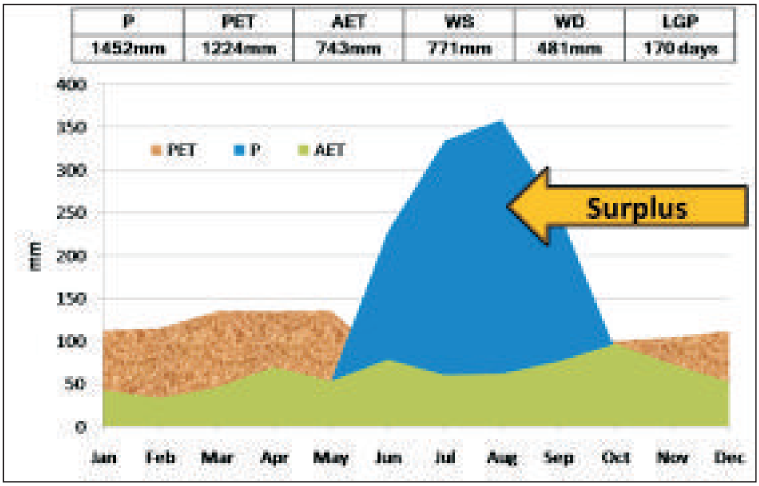


Figure 2.3: Water balance diagram of the LPG watershed

2.3 Soils and LCC

The soils are red with sandy clay loam in texture. Acidic in reaction, medium in organic carbon (0.69%), soil available nitrogen (288 kg ha^{-1}) and phosphorus content (11.1 kg ha^{-1}) and high in potassium content (313 kg ha^{-1}). The LCC of the watershed revealed that, the maximum area is under class III (43.1%) followed by class VI (22.6%) and class VII (20%). The class II and IV account for 6.6 and 7.7% of the total watershed area, respectively. The class II is under paddy cultivation and the majority of the class III & IV under rain-fed crops of paddy and ragi. Whereas class VI and class VII land is under degraded forest and shifting cultivated area. The detailed LCC map is presented in Figure 2.4.

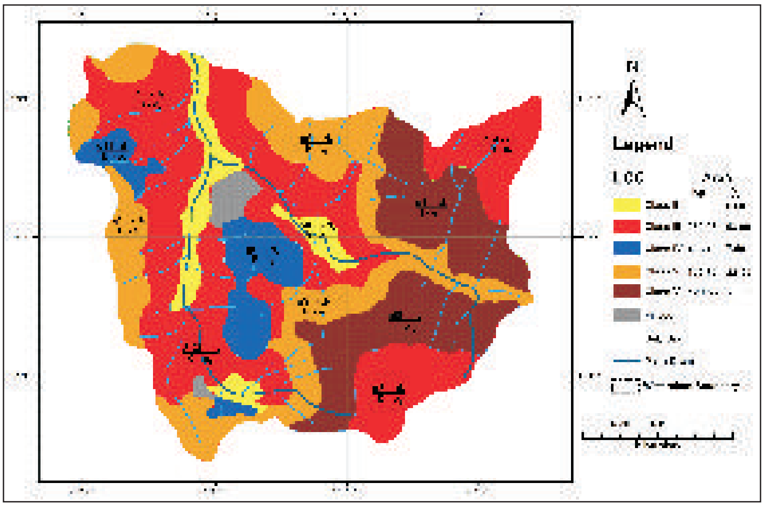


Figure 2.4: Detailed LCC map of the LPG watershed

2.4 Geology and Geohydrology

The area possesses lithology mainly composed of shale, slate and sand stones showing faults and fissures. The weathered and fractured granite/ granitoid gneiss constitutes the major repository of groundwater. Besides these aquifers, weathered and fractured Khondalites, journalists Shale etc. also form aquifers about the small areal extent of low to moderate yield. Groundwater occurs in unconfined to confined conditions. Groundwater from shallow and deeper aquifers is suitable for irrigation, drinking and other purposes.

Photo 2.1: General view of the LPG watershed

2.5 Drainage

The LPG watershed is a part of the Upper Kolab river catchment. Due to undulating topographic conditions, rainwater draining ultimately into Jhola system and finally drains into the Upper Kolab river. The drainage pattern is having fine texture of dendrite pattern. This indicates that the rock formations are impervious and permeability is low. Soils formed in such areas are deep, heavy and slowly permeable. Thus, the area is very prone to severe erosion hazards forming gullies.

2.6 Vegetation

The vegetation type is tropical scrub forest. The average density of trees on private land is 7 ha^{-1}. Very high intensity uncontrolled grazing and browsing by livestock, heavy extraction of trees for fuel wood and practice of shifting cultivation are the major threat to vegetation in the watershed areas. The vegetation details are presented in Table 2.2. Extensive dependence on forest for fuel and fodder are the primary reasons for causing degradation of natural vegetation in the watershed area (Table 2.3).

Table 2.2: Vegetation details in the LPG watershed

Particular	Description
Forest type	Tropical Scrub Forest
Average tree density on private land (No ha^{-1})	7 (Scattered trees in the upper and middle reaches and no tree occurrence in the lower reaches)
Tree species in agricultural land & in homestead garden	Scattered trees of *Mangifera indica (Mango), Tamarindus indica (Tamarind), Artocarpus heterophyllus (Jack fruit), Pongamia pinnata (Karanj), Terminalia bellarica (Bahada), Grevillea robusta (Silveroak), Bambuseae (Bamboo), Bixa oriliana (Jafra), and Caryota urens (Fish tail palm)*
Small trees/ Shrubs	*Mallotus phillipensis, Lania coramadalica, Grevia telifolia, Gmelina arboria*
Herbs *Ferns*	*Diospyros spp., Holarina antidecentrica, Murraya koenagii, Glycosmis pentaphylla, Eupatorium, Lantana camera, and some medicinal herbs*
Economic important plants	*Bauhinia vahlii*- Leafy vegetable *Terminalia bellarica*- medicinal use *Caryota urens*- alcohol production
Weeds Infestation	The entire forest area is infested with obnoxious weeds such as *Lantana camera* and *Eupatorium*

Table 2.3: Fuel wood and fodder requirement in the LPG watershed

Particular	Quantity (t yr^{-1})
Total fuel wood requirements	690
Fuel wood from agriculture	276
Fuel wood from forest	414
Total Fodder requirement	905

2.7 Land Use

Out of the total geographical area of 601.24 ha, maximum area is under degraded forest (61%) followed by the net cultivated area (20.15%), current fallow (11.5%), area under non-agricultural use (6.0%) and area under pasture land (1.4%) (Figure 2.5). The land physiography as per tirbal nomenclature is presented in Annexure.

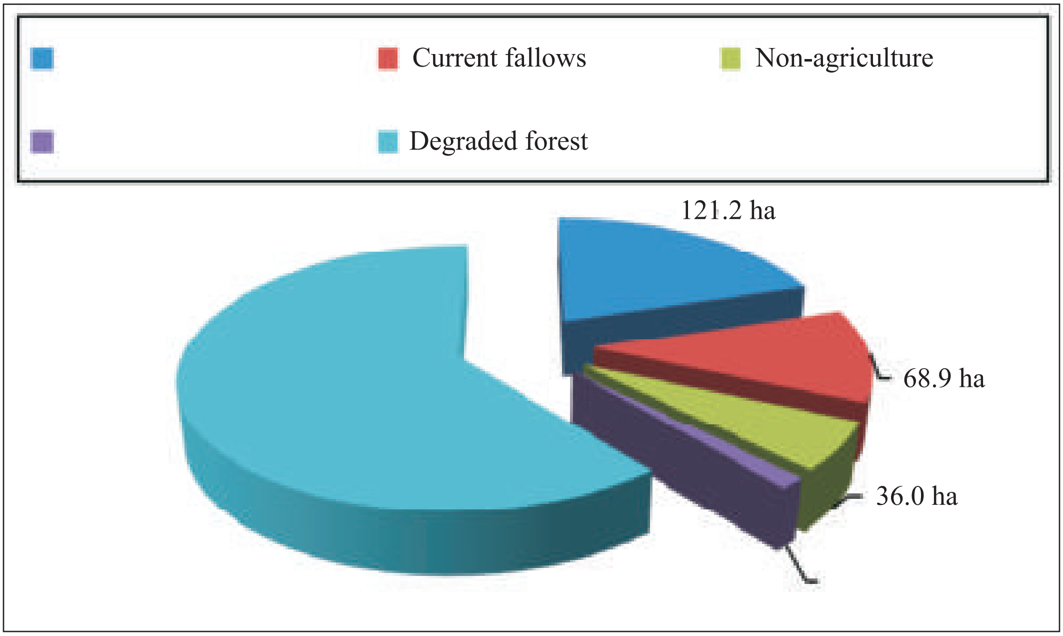


Figure 2.5: Major land use in the LPG watershed

2.8 Water Resources

The presence of springs in upper hills, small perennial streams and downstream flow in jhola beds are the major sources of water resources available in the watershed. Though the watershed receives high rainfall during monsoon season but acute water scarcity during post monsoon due to drying of springs and decreased downstream flow is the common feature.

2.9 Crops

The major crops grown in the watershed are low and upland paddy, ragi and niger during *kharif*. The farmers occasionally go for vegetable cultivation in their field subject to availability of water. Mostly farmers do not grow crops in the post-monsoon season due to lack of water availability and fear of crop failure.

2.10 Demography

The LPG watershed has a total population of 992 living in 315 households. Tribal population accounts about 66% of the total population of the watershed. Major occupation is agriculture and landless labours. The average land holding is 0.52 ha and an average family income is ₹2500/- per month. The detailed socioeconomic status of the watershed is presented in Table 2.4.

Table 2.4: Socioeconomic status in the LPG watershed

S.No.	Socioeconomic Indicators	Status					
1	Household (HH)	Total HH	SC	ST	Others		
		315	87	661	244		
2	Total Population	992					
3	Tribal Population	661 (66%)					
4	Landless Family	84 (27%)					
5	Sex Ratio (Male: Female)	01:01.0					
6	Major Tribes & SC	*Kandha, Paroja and SC is Domb*					
7	Housing	Thatched, Tailed & Sheet roofs					
8	Major Occupation	Agriculture (62%)					
9	Labour Force	Male	Female	Total			
		256	146	402			
		Agric	Daily wage	Mine workers	Migratory		
		249	100	38	15		
10	Unemployed Youths	30%					
11	Literacy Rate	29.6% (Male: 22%, Female: 7.6%)					
12	Average Annual Income	₹ 23768/-					
13	Average Land Holding (ha)	0.52 (Per capita agricultural land: 0.12 ha)					
14	Livestock	Cattle	Buffalo	Pig	Goat	Poultry	Sheep
		403	25	43	95	428	97
15	Primary School	Two					
16	School Children	Boys	Girls	Dropout	Total		
		105	55	45	160		
17	Drinking Water Source	Hand pumps					
18	Road	Black topped roads					
19	Nearest Place for Other Facilities	Damanjodi (5-8 km)					

2.11 SWOT Analysis

Table 2.5 presents the major strength, weakness, opportunities and threat in the LPG watershed.

Table 2.5: SWOT analysis of the LPG watershed

Strengths	Weaknesses	Opportunities	Threats
Diversified topographic land features	High soil erosion on sloping lands	Potentials for diversified land use options with conservation measures	Land degradation and declining productivity
A perennial source of water in main streams	Poor water resource development and use of rainwater for productive purpose	Water resource development for increasing crop area and efficient use of rainwater	Water scarcity for domestic and agricultural use cause unrest among the community
Existence of strong social integrity among the tribal community	Exploitation of tribal community by others	Use of participatory approach to development of watershed	Social conflicts due to weak social integrity
Eco-friendly farming with non greedy mentality of the community	Low productivity and nutritional status	Scope for application of best management practices to improve productivity and nutritional security	Vicious cycle and malnutrition which reduces efficiency of work
Well connected roads and local markets	Exploitation by the middle man and low price for farm produce	Formation of Groups (SHGs & UGs) and establishing market linkages	Community and youths move away from farming due to non-profitability
Presence of various R&D and other developmental organization including programmes and schemes	Poor co-ordination and programme implementation	Scope for convergence approach and establishing co-ordination with other organization.	Credibility on the mandates of various organizations and poor impacts of developmental programmes/project s/schemes

Photo 2.2: Degraded shifting cultivated area and poor socio economic condition in the watershed

3 WATERSHED DEVELOPMENT ACTIVITIES

3.1 Project Implementation Strategies

The programme was implemented following a participatory approach with active community participation at all the stages of the project. The bottom line approach in this programme was to develop it into a self sustaining programme through community capacity building during the preparatory phase of the watershed programme and to maintain sustainability after withdrawal of the project. At all the stages of project implementation "Common guidelines for watershed development projects" (NRAA, 2008) was followed.

Photo 3.1: Inauguration of the watershed by the District Collector, Koraput

3.2 Community Organization and Capacity Building

Community organization is considered to be an important component of any rural development project. A multidisciplinary team of scientists and technical officers constituted watershed development team (WDT) who conducted several rounds of meeting with the watershed community. Participatory rural appraisal (PRA) exercise was conducted to generate awareness about the project and its mode of operation and execution. Further, exposure visits to successfully executed watersheds were conducted to build confidence of the watershed communities and several entry point activities (EPA) were taken by the WDT in the watershed with the community contributions (Table 3.1). Watershed level local people's institutions represented by various sub-communities of the watersheds were constituted for implementation and execution of various watershed development activities (Table 3.2).

Photo 3.2: Community organization & capacity building activities

Table 3.1: Activities taken to generate awareness and community confidence building in the watershed

Activity	Year				Total
	2007-08	2008-09	2009-10	2010-11	
Village meetings	5	3	2	1	11
No to anti-liquor campaign	3	2	1	-	6
Campaign for health and hygiene	3	2	1	-	6
Motivation for enrollment of children in school	1	1	1	1	4
Wall paintings depicting benefits of the watershed programme	12	12	6	-	30
Participation in exhibitions	1	1	1		
Campaign for saving in bank account	1	1	1	-	3
Newspaper reading	*	*	*	*	

Photo 3.3: Human and animal health camps organized at the watershed

Table 3.2: Details of local level institutions at the watershed level

S. No.	People's Institute	No. Group	Total Member	Activity/Role
1	SHGs	15	237	Tailoring, Pickle and sauce making (Household production system), Mushroom farming, Honey production, Cow rearing, Goat rearing and Backyard Poultry.
2	Watershed Committee	01	13	Overall coordination and liaison, execution of watershed development activities and other activities as per the guideline. WPA: SBI, Damanjodi, Account no. 30863631781.WDFA: Utkal Gramaya Bank, Mathalput, Damanjodi bearing account number SBO 164.

3.3 Interventions for Watershed Development

Various interventions were undertaken in the watershed based on the problems, needs, priorities of the watershed community and their technical suitability and economic viability. The watershed development activities taken in the watersheds are soil and water conservation measures in arable lands, water resource development, productivity enhancement activities, entry point and income generation activities and community organization including capacity building (Table 3.3).

Table 3.3: NRM, production, IGA, EPA and capacity building activities in the LPG watershed

S.No.	Activity	Unit	Quantity
	I. Conservation Measures		
1	Vegetative filter strips	rm	300
2	Field bunding	ha	32.7
3	Hedge plantation	ha	17
4	Stone bunding	ha	9
5	Trenching	ha	13
	II. DLT Measures		
1	Live check dam	No	35
2	Brushwood check dam	No	30
3	LBCD	No	44
4	Gabions	No	13
5	Stream bank stabilization	rm	1124
	III. Productivity Enhancement		
1	Agri-horticulture system	ha	8
2	Bamboo plantation	ha	1.5
3	Fuel and fodder plantation	ha	2
4	Biodiesel plantation	ha	1.5
5	Silivi-pasture system	ha	1
6	Agronomic interventions	No	7
	IV. Water Resource Development		
1	Farm pond	No	6
2	Jhola kundi	No	20
3	Renovation of WHS	No	2
4	Renovation of pipeline system	No	1
V	Income generating activities	Group	15
VI	Entry point activities	No	5
VII	Capacity building	No	49

4 MONITORING AND IMPACT ASSESSMENT METHODOLOGY

The present study on impact analysis is based on the baseline data collected during 2008 and data monitored and collected during the project implementation period till June 2013. Data on bio-physical and socioeconomic parameters were collected through field visits, detailed resource survey, household survey, PRA techniques, meeting, interviews and FGDs during pre-project and post project implementation of the watershed project. Periodic monitoring and measurement of hydrological, soils, growth parameters and yield of crops, horticultural and forest plants, land use, social and economic parameters were collected. Two gauging stations were installed for runoff monitoring. Siltation behind check dams, DLTs and ponds were also measured periodically at selected places during the implementation phase of the watershed. Soil samples from different depths (0-15 and 15-30 cm) were collected from selected plots/pits at initial and at the final stage of the project. Crop wise yield was recorded for selected plots in farmers' fields. Survival rate and growth parameters of fruit and forest trees were recorded periodically. The storage capacity of water harvesting structures was quantified through detailed contour survey and measurements. Besides biophysical data, socioeconomic data in terms of contribution, change in income, income from SHGs, participation of the community in different activities *etc*., were collected through pre-tested questionnaires and interviews. Data on expenditure incurred on various activities of watershed development were compiled from the expenditure statements.

4.1 Impact Indicators

Impact of various interventions on biophysical, participatory, and socioeconomic aspects in the watershed was assessed through different impact indicators (Table 4.1). Pre and post project approach was adopted for impact assessment. The appropriate statistical techniques and tools were used to analyze the primary data. The post project impact assessment of investment on watershed activities in the village was carried out to examine the efficiency of economic returns, etc.

Table 4.1: List of impact indicators used for evaluation of impacts of watershed development activities

S.No.	Impact Indicator	Methodology
1	Crop Diversification Index (CDI)	Sikka *et al.*(2004); Sharda *et al* (2005)
2	Cultivated Land Utilization Index (CLUI)	Chuang (1973);Sikka *et al.*(2004); Sharda *et al* (2005)
3	Crop Productivity Index (CPI)	Sikka *et al.*(2004); Sharda *et al* (2005)
4	Crop Fertility Index (CFI)	Sikka *et al.*(2004); Sharda *et al* (2005)
5	Induced Watershed Eco-Index (IWEI)	Sikka *et al.*(2004); Sharda *et al* (2005)

6	People's Participation Index (PPI)	Katar Singh (1992)
7	BCR & IRR	Gittinger (1972); Gittinger (2004)
8	Storage Capacity of Ponds	Capacity survey
9	Ground Water Table	Periodical measured in Open wells
10	Soil Fertility Status	Jackson (1973)
11	Density of Trees in Agricultural Land	Survey technique (Total trees in the agricultural land to the total agricultural area)
12	Watershed Productivity (WP)	Sikka *et al.(*2004); Sharda *et al* (2005)
13	Water Use Efficiency (WUE)	Allen *et al*. (1998)

4.2 Estimation of Potential Soil Erosion Rates (PSER)

The potential soil erosion rate was estimated using the USLE distributed parametric approach for the pre and post project periods in the watershed (Wischmeier and Smith, 1960). The different parameters of USLE *viz*., R, K, LS, and CP factors were estimated following the methodology of Wischmeier and Smith (1978); Wischmeier *et al.* (1971); Wischmeier *et al.* (1960) and Tejwani *et al.* (1975), respectively.

4.3 Estimation of Runoff

The runoff was estimated using hydrologic soil cover complex (curve number) method. This method is based on the recharge capacity of the watershed which is determined by antecedent moisture conditions and physical characteristics of the watershed. Based on the hydrologic soil group and land use cover, the curve number (CN) value was determined and used to find out the potential maximum retention (S) (USDS-SCS, 1972). The CN values for AMC II condition was used with the correction factor for AMC I and AMC II conditions. Then the runoff was estimated using the rainfall-runoff relationship.

4.4 Energy Efficiency of Rainwater (EERW)

Energy efficiency of rainwater is the ratio of energy output (co-efficient) value of the unit crop produce (Alipour *et al.,* 2012; Gundogmus, 2006; Tuti *et al.,* 2012; Singh, *et al.,*2008) to the energy co-efficiency of water. The energy co-efficient of water was taken as 0.63 MJ m^{-3} of water (Gundogmus, 2006).

4.5 Estimation of Carbon Sequestration Potential of Plantation

The periodical bio-physical parameters viz., survival rate, basal diameter and height of each plantation were monitored. Based on these growth parameters, future attainable biomass were estimated for 10 and 20 years using the allometric equation (Brown, 1997) is given below.

$Y = \exp[-2.134 + 2.530 * \ln(D)]$

Where, Y=biomass per tree in kg, D=dbh in cm

The carbon content of the plantation was calculated by multiplying their biomass value with 0.45 in general, this ratio is used for tropical trees (Negi *et al.,* 2003).

4.6 Technical Man Days at Different Phases of Watershed Development

Actual scientific and technical staff involved at three different phases of the watershed development was calculated based on the contributions of each staff associated in the project period. Technical man days were calculated per ha basis for the entire watershed and the treatable watershed area at three watershed phases and expressed man days per ha.

5 RESULTS OF IMPACT ASSESSMENT

5.1 Bio-Physical Impacts

5.1.1 Potential soil erosion rate (PSER)

Potential soil erosion in the watershed was estimated for pre (2008) and post (2012) project period (Figure 5.1). During the pre project period, the maximum area under PSER was in the erosion class of >40.0 t ha^{-1} yr^{-1} (20.4%) followed by 15-20 t ha^{-1} yr^{-1} (18.2%) and 10-15 t ha^{-1} yr^{-1} (18.0%) and this was due to the absence of suitable conservation measures and vegetation cover in the watershed (Figure 5.2). However during the post project period, the percent area under high erosion classes (moderate to very high) decreased and these areas shifted towards lower erosion classes (very low and moderately low). This reduction in PSER from higher erosion classes to lower classes was attributed to various conservation measures taken in the watershed which contributed towards reducing the length of slope by field bunding and decreased CP factors due to vegetation cover coupled with bunding and trenching. The average PSER in the watershed for pre and post project period is estimated to 30.24 t ha^{-1} yr^{-1} and 25.03 t ha^{-1} yr^{-1}, respectively (Figure 5.3). The average actual soil deposited in the trenches was calculated from the silt deposition data and workout to 13.69 t $ha^{-1}yr^{-1}$ of soil was actually arrested on the site otherwise this soil would have deposited in the streams and water storage structures.

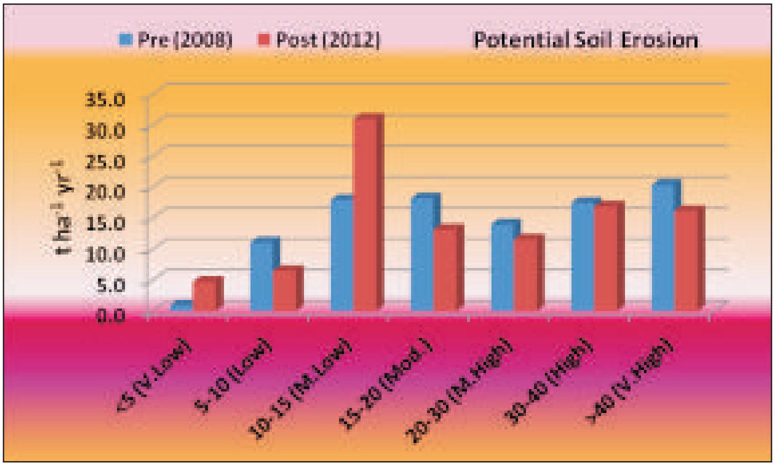


Figure 5.1: Potential soil erosion rate during the pre and post project period in the LPG watershed

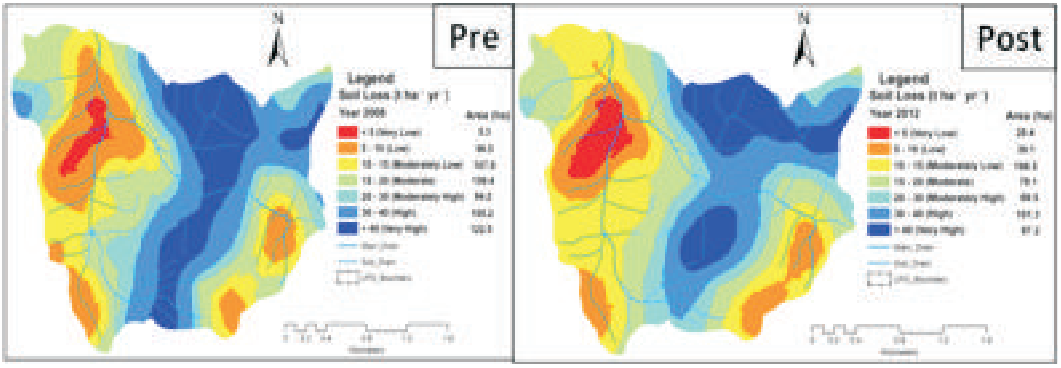


Figure 5.2: Potential soil erosion map for pre and post project period in the LPG watershed

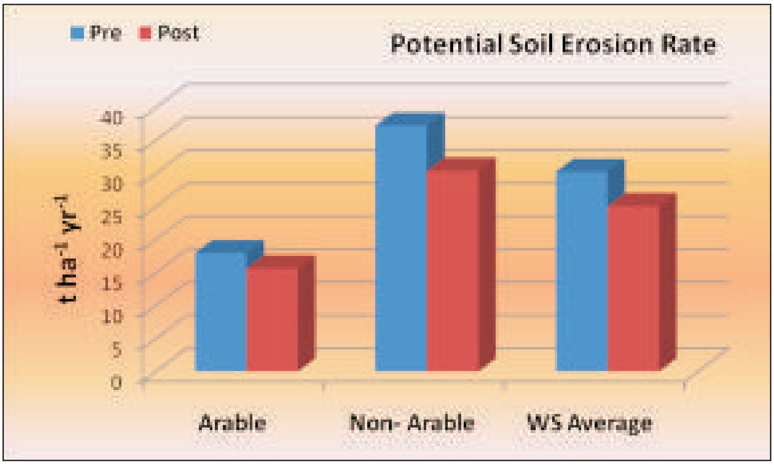


Figure 5.3: Average PSER in the watershed area

5.1.2 Runoff

The estimated runoff for different land uses in the watershed varied from 14.68 to 29.92% and 7.3 to 15.4 % for the pre and post project period, respectively (Figure 5.4). The maximum runoff was observed in ragi and upland paddy (29.92%) during pre project period and it decreased to 15.4% in post project period due to field bunding in degraded sloping lands. The average estimated runoff in the watershed decreased to 14.6% during post project period from 24.4% in pre project period.

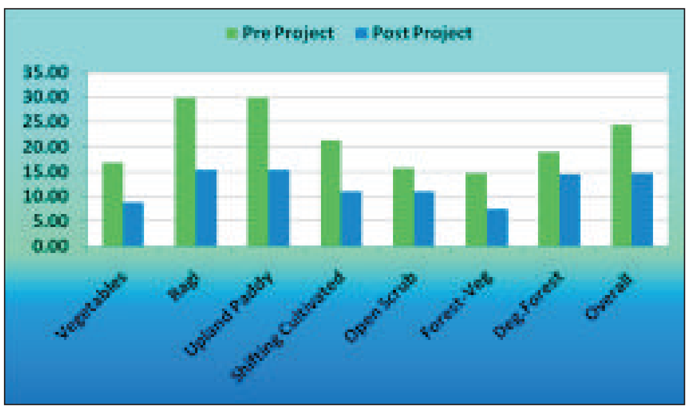


Figure 5.4: Estimated runoff under different land use during pre and post project period in the watershed.

Photo 5.1: Field bunding in slopping degraded arable land: Pigeon pea and marigold on the field bund

Photo 5.2: Trenching in non-arable land for rainwater harvesting

5.1.3 Water resource development

The interventions such as dugout ponds, lined ponds, jhola kundi and check dams were taken up in the watershed to increase the rainwater storage and availability in the watershed. A total of 93.91 ha-cm rainwater storage capacity was created and harvested in the watershed (Figure 5.5). An additional area of 24.2 ha is brought under protective irrigation for cultivation of paddy and vegetables benefiting 177 beneficiaries in the watershed (Table 5.1).

Photo 5.3: Water convey channel to irrigate paddy and vegetable crops

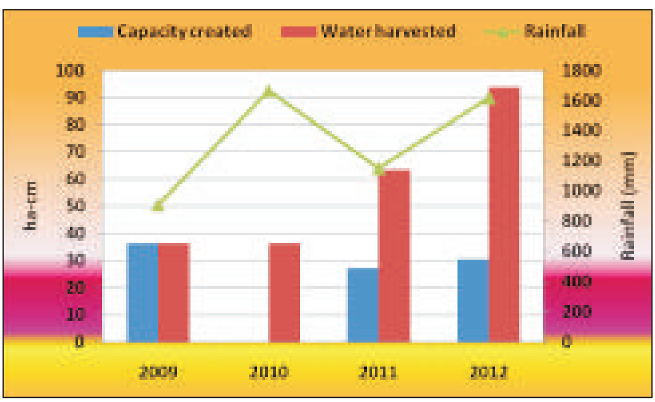


Figure 5.5: Rainwater storage capacity created and harvested during the project period.

Table 5.1: Impact of water resource development on irrigated area and beneficiaries in the LPG watershed

Water harvesting structure	Cost (₹)	Irrigated area (ha)			Crops grown	Beneficiaries
		Before	After	Additional		
Convey channel (Ariputraghati)	2,19,476	2	6	4	Paddy and Ragi	30
Check dam-I (Ariputraghati)	48,636	0	6	6	Paddy and Vegetables	52
Check dam-II (Ariputraghati)	78,034	0	1.6	1.6	Paddy	17
Check dam-III (Ariputraghati)	1,24,878	0	2	2	Paddy and Vegetables	12
New farm pond	99,641	0	3.2	3.2	Paddy and Ginger	14
Convey channel	66,006	3.6	13	9.4	Paddy and Vegetables	52
Total	**6,36,671**	**5.6**	**29.8**	**24.2**		**177**

5.1.4 Depth of water table

The average water table depth raised by 0.18 m (5.9%) and the depth of water storage in the well increased by 0.17 m (17.8%) during the post project period compared to pre project period (Figure 5.6). The rise in water table depth was more prominent during post monsoon months. The rise in the water table and depth of water storage in the well was attributed to the increased base flow due to implementation of soil and water conservation measures in the watershed.

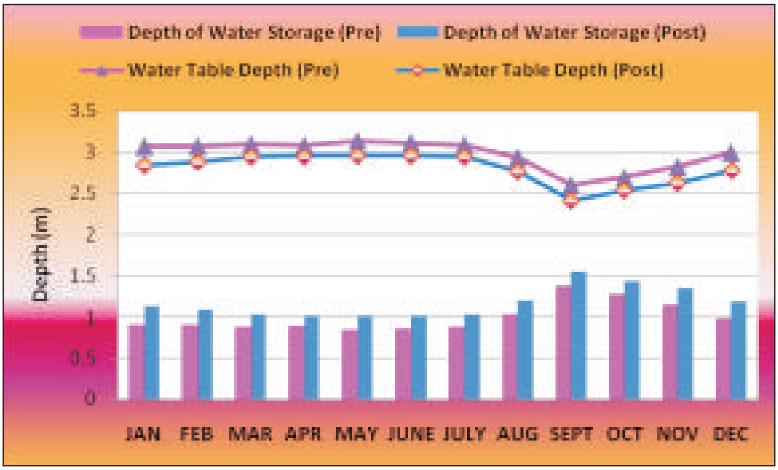


Figure 5.6: Depth of water storage and water table depth in open well during the pre and post project period in the watershed

Photo 5.4: Rainwater harvesting pond for multiple use of water in the watershed

Photo 5.5: Silpauline lined pond for rainwater harvesting to provide protective irrigation to mango plantation

5.1.5 Productivity of crops and crop diversification

A total of 45.4 ha area has increased under cereals, pulses and oil seed crops during the project period and similarly area increased under horticultural crops to the extent of 24 ha (Figure 5.7). The average yield of different crops was collected for pre and post project period from the watershed areas and presented in Figure 5.8. The yield of all the crops has increased considerably in the range of 3 to 15% with the overall average increase of 9.14%.

Due to increase in water availability and high market demands, efforts were made for popularizing cultivation of vegetables in the watershed areas. As a result the area under vegetable cultivation has been increased by 30% over pre-project period (from 31 ha to 40 ha). Crop Diversification Index (CDI) was worked out based on the area under each crop in different seasons for the period before and after the project. CDI values near to 1 indicate complete diversification. The overall pre-project CDI was 0.55 and it was increased to 0.71 during the post project period registering an increase of 30%. A similar increase in productivity and CDI was also reported by Sikka *et al.* (2004) and Dass *et al.* (2009) under watershed programmes.

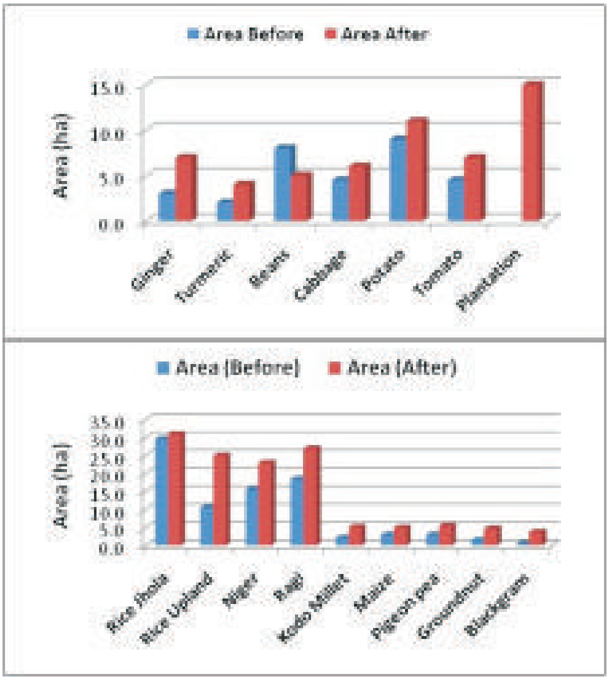


Figure 5.7: Area under different crops during pre and post project period

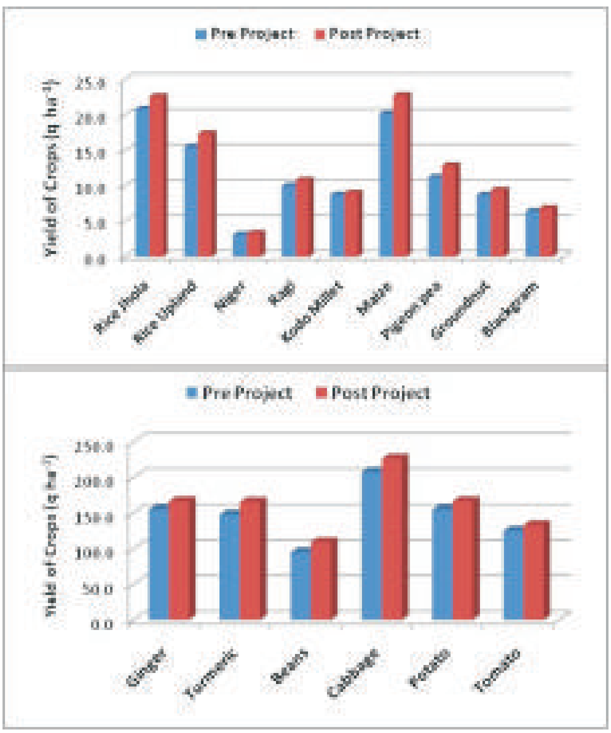


Figure 5.8: Yield of crops during pre and post project period

5.1.6 Cultivated land utilization index (CLUI)

Cultivated land utilization index was worked out for the period before and after the project. CLUI is calculated by summing the products of land planted to each crop, multiplied by the actual duration in days of that crop, divided by the total cultivated land area times 365 days. CLUI increased by 0.05 from 0.35 to 0.40 in the watershed areas as a result of the large scale introduction of horticultural plantation in dry land and increased area under irrigation. This indicated that irrigated area was put under intensive cultivation with high value commercial crops. This also clearly indicated the impact of watershed interventions reflected in the increase in the cultivable land area and duration of crop cultivation.

Photo 5.6: Crops grown with improved package of practices

5.1.7 Crop productivity index (CPI)

Crop productivity index indicates the extent of crop productivity level in comparison to the normal yield of crops as per the package of practices. It was calculated by using farmers' yield data and normal yield of crops as per the package of practices to evaluate changes in the productivity level of crops which are grown in the watershed. Overall CPI was increased from 0.547 during the pre project period to 0.613 after the project, registering an increase of 12% in the productivity level of crops and it was partly due to distribution of inputs viz., seeds and fertilizers.

5.1.8 Crop fertilization index (CFI)

Crop fertilization index indicates the extent of crop nutrients (NPK) applied to the crop in comparison to the recommended level of nutrients to that crop. Overall CFI increased from 0.21 during the pre project period to 0.30 after the project, registering an increase of 43% in rate of nutrient application. In general, vegetable crops are fertilized more than the grain crops due to better price for vegetable crops. This was partly due to distribution of inputs during the project period. The CFI is still low indicates that NPK consumption in the watershed areas is very less than half of the recommended dose of nutrients to the crops.

5.1.9 Watershed productivity (WP)

Watershed productivity indicates the overall productivity level in the watershed. This was calculated by taking the yield of crops, cropped area and output price of different crops grown in the watershed and expressed in equivalent yield of dominating crops in the area. Overall watershed productivity was expressed in equivalent yield of ragi. The overall WP increased from 4962 kg ha^{-1} of ragi during pre project period to 6126 kg ha^{-1} after the project period. This was mainly due to increased area under irrigation, slightly increased productivity of crops and diversification of crops towards vegetable crops. The increase in WP was 19% and this was attributed to increased area under vegetable cultivation which are highly remunerative than any grain crops grown in the watershed. Deshpande and Reddy (1991), Dhyani *et al*. (2001), Shah (2001), Joshi (2004) and others have reviewed different dimensions of watershed management and these studies have focused on the positive impact of watershed management on cropping, agricultural productivity, employment generation and increase in income, amongst others.

5.1.10 Induced watershed eco-index (IWEI)

Induced watershed eco index is used to represent the fraction of green area in the watershed. This represents an additional area made green through watershed treatment as a proportion of the whole watershed area. The value of IWEI observed found to be 0.04, suggesting that an additional 4% of watershed area was rehabilitated through green biomass cover.

5.1.11 Dry land horticulture

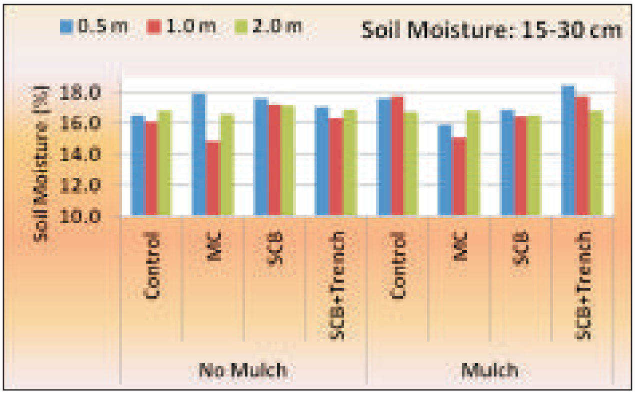
Prominent cultivation of mango *(Mangifera indica)* was introduced in the watershed area. The average overall survival percent of fruit plants at the end of five years is 68%. Economic analysis was done for a mango plantation under rainfed condition by projecting costs and benefits up to 15 years to know the economic viability. Benefit cost analysis was carried out at 10, 15 and 20% discount rates. The BCR worked out to be 3.01 and 2.75 at 10 and 15% discount rates, respectively for mango with the Internal Rate of Return (IRR) of 21.28%. Due to Agroforestry interventions, the density of trees, particularly in dry land, increased to 14 trees ha^{-1} from 7 trees ha^{-1}.

Photo 5.7: Agri-horticulture system (Mango+Ragi) with conservation measures and pitcher irrigation in the watershed

5.1.12 In-situ rainwater conservation measures in mango plantation

In newly planted mango plantation in-situ rainwater conservation measures viz., micro catchment (MC), semi-circular bunds (SCB), SCB with trenching on the upstream side of plants were studied with and without mulching in the watershed. Soil moisture content at 0-15 and 15-30 cm was determined at three locations from each plant (0.5 m, 1.0 m and 2.0 m on downstream side of the plant) during 2012 and 2013. Soil moisture content was higher at 15-30 cm compared to 0-15 cm in all the treatments (Figure 5.9). The average soil moisture content at both the depths with mulching was higher by 9.16 (0-15 cm) and 5.56% (15-30 cm) over treatments with no mulching. In general, soil moisture content was high at 0.5 m compared to 1.0 and 2.0 m away from the plant due to in-situ rainwater conservation measures. Among the in-situ rainwater conservation measures, SCB and SCB with trenching conserved rainwater efficiently in the soil which was reflected in soil moisture content at both the depths. The influence of in-situ rain water conservation on growth parameters of mango plants is presented in Table 5.2. The growth of mango plants was better in all the conservation measures as compared to the control due to increased soil moisture availability in the soil.

Photo 5.8: Mango plantation with in-situ rainwater conservation measures



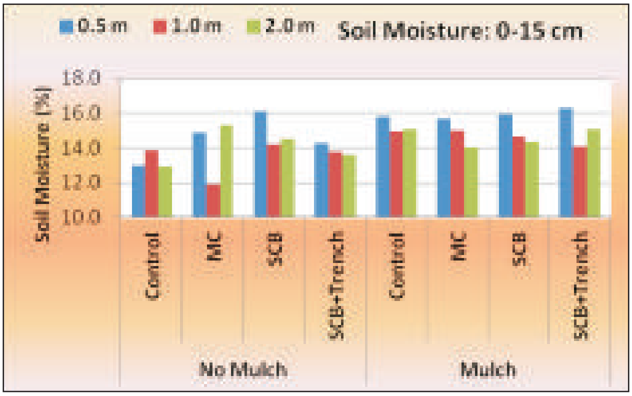


Figure 5.9: In-situ rainwater conservation measures on soil moisture content in mango plantation.

Table 5.2: In-situ rainwater conservation measures on growth of mango plantation

Treatment		Height (cm)		Basal Diameter (cm)	
		2012	2013	2012	2013
No Mulch	Control	67.7	120.9	1.8	3.4
	MC	70.5	124.8	2.2	3.7
	SCB	70.7	125.9	2.0	3.7
	SCB+Trenching	70.2	124.0	1.9	3.8
Mulch	Control	67.9	122.5	1.8	3.7
	MC	72.4	127.6	2.1	4.0
	SCB	70.3	126.0	2.1	3.8
	SCB+Trenching	70.6	125.8	2.0	3.9

5.1.13 Rainwater use efficiency(RWUE) and water productivity (WP) of crops

Rainwater use efficiency of the rain-fed crops is calculated and presented in Figure 5.10. Maximum RWUE was in the upland paddy (4.49 kg ha^{-1} mm^{-1}) followed by Maize (3.77 kg ha^{-1} mm^{-1}) and low land rice (3.00 kg ha^{-1} mm^{-1}) among the cereals. Among the pulses and oilseeds, RWUE was maximum in Red gram (1.81 kg ha^{-1} mm^{-1}) and groundnut (1.48 kg ha^{-1} mm^{-1}), respectively. Among the vegetable crops, maximum RWUE was in the cabbage (57.4 kg ha^{-1} mm^{-1}) followed by ginger, turmeric and tomato (Figure 5.11).

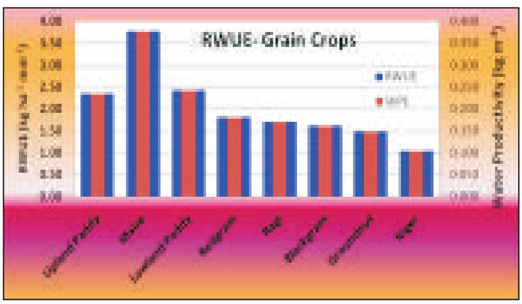


Figure 5.10: RWUE and WPC (Grains) in the LPG watershed

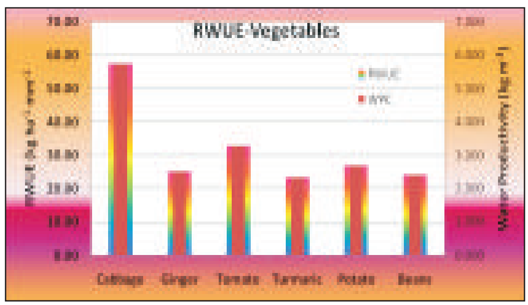


Figure 5.11: RWUE and WPC (Veg.) in the LPG watershed

Similarly water productivity of crops followed the same trend that of the RWUE of crops. Maximum productivity per unit of water was in the upland paddy (0.45 kg m^{-3}) followed by maize (0.38 kg m^{-3}), lowland paddy (0.3 kg m^{-3}), red gram (0.18 kg m^{-3}) and ragi (0.17 kg m^{-3}). Water productivity of vegetables in the watershed varied between 2.4 kg m^{-3} (Beans) to a maximum of 5.7 kg m^{-3} (Cabbage) of water (Figure 5.11). Gross returns per unit of water used to produce was much higher from spices followed by vegetable crops compared to that of cereals, oilseeds and pulses (Table 5.3) and thus farmers prefer to cultivate vegetables under assured condition of water availability.

Table 5.3: Gross returns per unit of rainwater for different crops in the watershed

Crop	Returns (₹m^{-3})	Crop	Returns (₹m^{-3})
Upland Paddy	4	Niger	4.2
Maize	6.4	Cabbage	45.9
Lowland Paddy	4.1	Ginger	100.8
Red gram	13.5	Tomato	32.9
Ragi	2.7	Turmeric	187.3
Black gram	8	Potato	26.9
Groundnut	5.2	Beans	48.3
Av. Cereals	4.3	Av. Oil Seeds	4.7
Av. Pulses	10.7	Av. Vegetables	38.5
		Av. Spices	144.0

5.1.14 Energy efficiency of rainwater (EERW)

The EERW varied between 2.5 and 6.65 MJ m^{-3} of rainwater for grain crops, for vegetables it ranged from 4.23 to 15.35 MJ m^{-3} of rainwater. Maize (6.65), paddy (5.61), and red gram (4.01) among the grain crops and potato (15.35) and cabbage (10.21) among the vegetables have high EERW in the watershed areas (Figure 5.12). The average EERW of all the crops in the watershed area is 5.53 MJ m^{-3} of rainwater which is equivalent to 1.32 kcal per liter of rainwater or 1.32 calories per ml of rainwater.

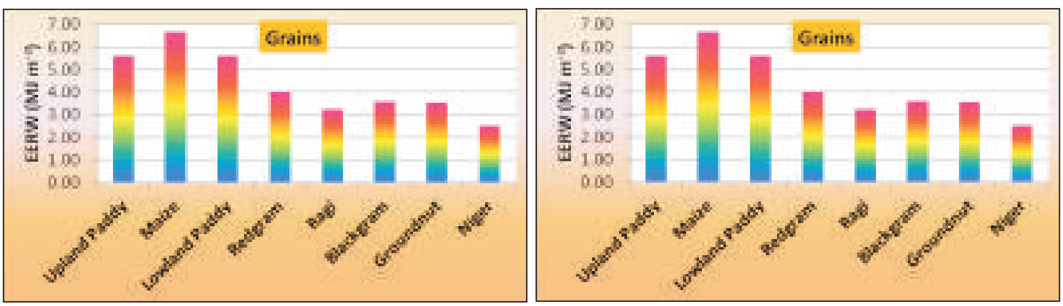


Figure 5.12: Energy efficiency of rainwater for grain crops and vegetables in the LPG watershed

5.1.15 Carbon sequestration potential

Total carbon sequestration potential was estimated for the projected period of 10 and 20 years for different plantations in the watershed considering the present survival rate and expected growth rate and stand of each plantation (Figure 5.13). The maximum carbon sequestration potential was from energy plantation followed by miscellaneous plantation, bio-diesel and Agri-horticulture plantations. A total of 391.24 t and 1114.65 t of carbon sequestration potential is estimated over 10 and 20 years, respectively in the watershed areas. The average carbon sequestration potential is workout to 2.12 and 3.4 t ha^{-1} yr^{-1} after 10 and 20 years, respectively from the plantation area in the watershed. Estimating the carbon credit at a carbon price of USD 20 t^{-1} of C (Atkinson *et al.,* 2006), it worked out to USD 42.8 (₹2544/-) and 68 (₹4080/-) ha^{-1} yr^{-1} after 10 and 20 years, respectively (1 USD=₹ 60/-).

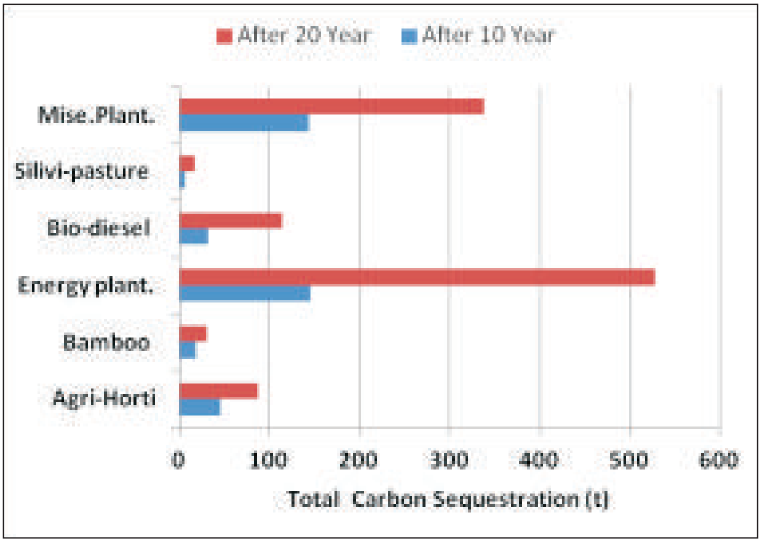


Figure 5.13: Estimated total carbon sequestration potential of different plantations

Photo 5.9: Aforestation with conservation measures in degraded sloping land

5.1.16 Human population carrying capacity (HPCC)

The human population (adult) carrying capacity (HPCC) of cultivated lands in the watershed was worked out as per their production potential during pre and post project period. The HPCC is the ratio of energy output from the land use or production system to the annual energy requirement of an adult. The energy output from each land use or crops was calculated based on the energy co-efficient value of each crop (Alipour *et al.,* 2012; Gundogmus, 2006; Tuti *et al.,* 2012; Singh, *et al.,* 2008). The annual energy requirement for an adult was calculated based on the daily energy requirement recommended by the NIN, Hyderabad (NIN, 2009). The HPCC of different crops is presented in Figure 5.14 and spatial demarcation in the watershed area is presented in Figure 5.15. The HPCC is lowest in niger (1.0) and the maximum in potato (12.2). Among the cereals, paddy in jhola land, upland paddy and maize have the HPCC of 4.9 to 6.6 during pre project period and 5.5 to 7.2 during the post project period. The HPCC of vegetables varied between 2.2 (Beans) and to 12.2 (Potato) during pre-project period and it was increased to 2.4 and 13.1 during the post project period due to increased in productivity of crops. The average HPCC of crops was increased to 4.4 during post project period from 4.0 during pre project period and registered an increase of 9.3% due to enhanced productivity of crops through watershed activities (Table 5.4).

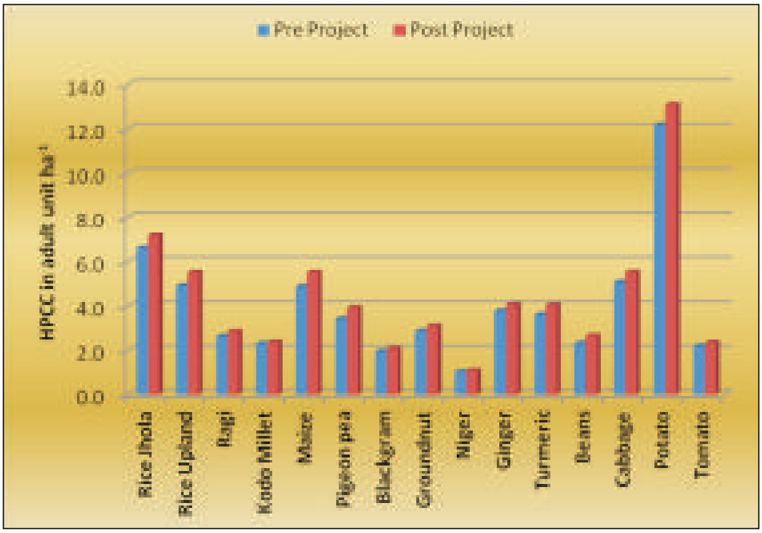


Figure 5.14: Human population carrying capacity of different crops in the LPG watershed

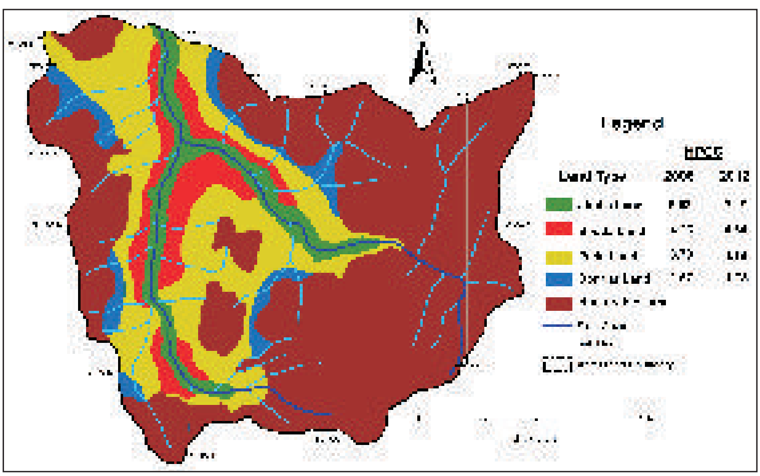


Figure 5.15: Human population carrying capacity of different land uses in the LPG watershed

Table 5.4: Average energy output and HPCC of land during pre and post project period in the LPG watershed

Particular	Pre	Post	Change (%)
AV. Energy output (MJ ha^{-1})	18296	20006	9.3
AV. HPCC of land (Adult ha^{-1})	4.0	4.4	9.3
Jhola land	6.6	7.2	8.5
Beda land	4.2	4.6	9.7
Padda & Donger land	2.7	3.0	8.5

5.2 Socioeconomic Impacts

5.2.1 People's participation

People's participation in watershed management project is an important index for its sustainability and it measured through People's Participation Index (PPI). The people's participation index was worked out at preparatory phase, watershed work phase and at the consolidation phase of the project (Figure 5.16). The overall PPI was found to be 56% indicating that the stake holder's overall participation was just above the medium level. Among the three stages of the project, the level of people's participation was highest (64%) at preparatory phase followed by 58% at work phase and 46% at consolidation phase indicating high to medium level of participation. This high level of people's participation could be attributed to the sincere, committed and devoted efforts of the WDT and watershed functionaries. Further, this could be attributed to the expertise of PIA in watershed management areas. Active people's participation is, therefore, highly critical in the success of the watershed program (Kerr *et al.* 2000; Joshi *et al.,* 2005). People's participation in planning, developing and executing the watershed activities is indispensable (Wani *et al.*, 2003a, b; Joshi *et al.,* 2005). Active and voluntary participation of all stakeholders guarantees the successful implementation of watershed program.

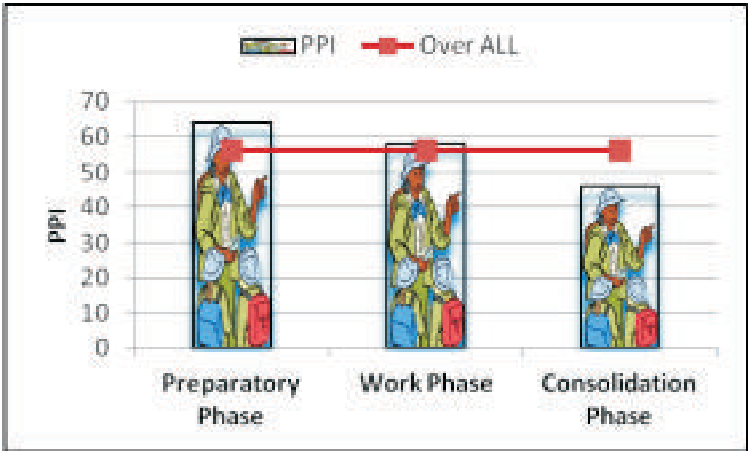


Figure 5.16: PPI at different stages of watershed development

5.2.2 Change in income and expenditure pattern

Income expenditure analysis is an important activity which insights into the real development of the watershed populace. The analysis was done before (2008) as well as after (2012) the implementation of watershed projects. The analysis was carried out on the basis of random sampling from all categories of farmers *viz.* large, medium and small. The analysis reveals that before the implementation for the project (2008) for large farmers the source of income was from an array of enterprises *viz.,* agriculture, animal husbandry and employment. After the implementation of the project (2012), there is a shift of income from non-institutional finance to agricultural activities to the tune of 5% (Figure 5.17). WDT has made efforts in capacity building of all categories of farmers for different income generation activities. Large farmers showed interest in initiating large scale enterprises i.e., poultry and livestock etc. In expenditure analysis, large farmer increase expenditure on inputs procurement and labour work by 5%. However expenditure on food and education remains unchanged.

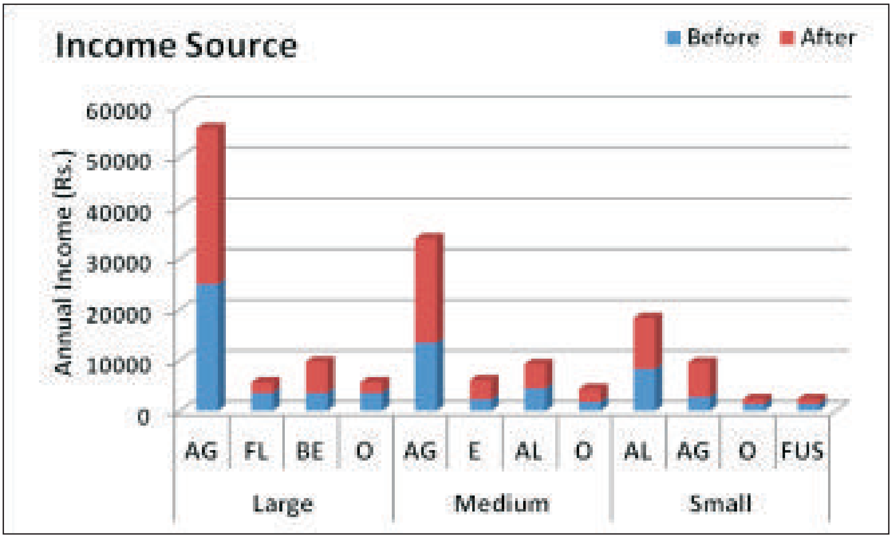


Figure 5.17: Source of income under different categories of farmers in the LPG watershed (AG:Agriculture, FL:Finance Lending, BE:Business/Employment, O: Others, AL:Agri.Labours, FUS:Fuel Wood Sale)

As per the initial income analysis (2008), a medium farmer income was depended on agriculture activities (60%) followed by labour work (20%). His expenditures were towards food, enjoyment and alcoholism which show his day-to-day living attitude. In 2012, medium farmer income source is shifted, to the tune of 5% of agricultural activities, which grossly contributes to 65%. In case of medium farmer, there was an increase in income for agricultural as well as in labour use by 5%. It signifies the consolidation of agriculture activities as for earning livelihood. For expenditure, a slight increase in expenses on credit facility and education by 15 and 2 %, respectively. For adoption of new activity medium farmers are approaching banks for credit (Figure 5.18). It shows the changing attitude of farmer for adopting new enterprises for livelihood development as well as providing quality education to his children.

Small farmers are most important to address the change for development and success. In Lachhaputtraghati watershed, the income analysis reveals that this change was more pronounced in their source of income. The agricultural activities showed increases of 15%. It shows the independence of farmers from labour work and their engagement in their own activity. A significant decrease of 5% in fuel wood sales shows the changing attitude and dependency on forests. The change in income from different sources for farmers showed a significant deviation in 2013 in comparison to 2008. On the expenditure side, a small farmer is accessing good food with increasing its expenditure on quality food by 4%. A drastic decrease in the expenditure of alcoholism by 8% and an increase in purchase inputs (12%) show a sea-change in the attitude of small farmer for improving his living conditions and leading a respectful life.

The income expenditure analysis shows the change in the behavior of farmer. The impact of different activities carried out by the implementing agency. The change and improvement in the income shows the success of the key objectives of watershed work phase.

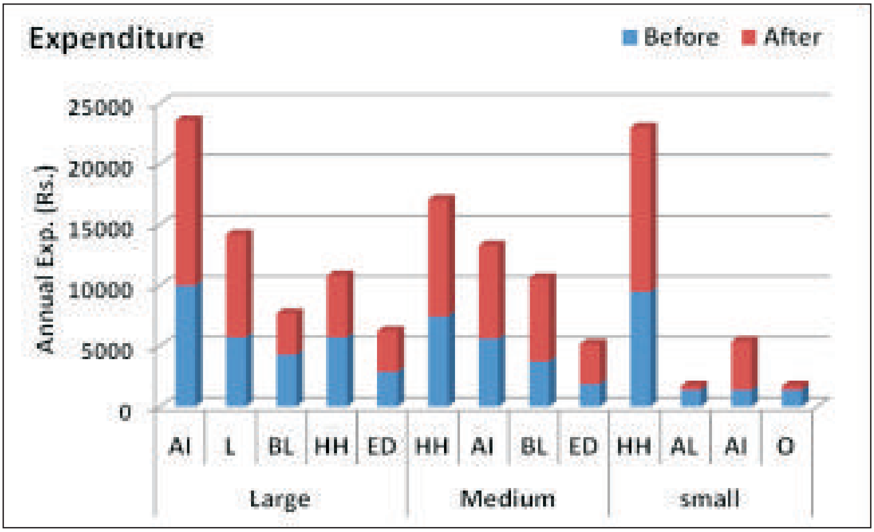


Figure 5.18: Expenditure pattern of different categories of farmers in the LPG watershed (AI: Agriculture Inputs, L:Labours, BL:Bank Loan, HH: House Hold, ED: Education,AL: Alcoholism & O: Others)

5.2.3 Employment generation

A total of 14052 man days employment was generated where in maximum employment generation was through water harvesting structures, DLTs and plantation works. Maximum employment generation was during the watershed work phase (84%) followed by a consolidation phase (15.3%) of the watershed development (Figure 5.19).

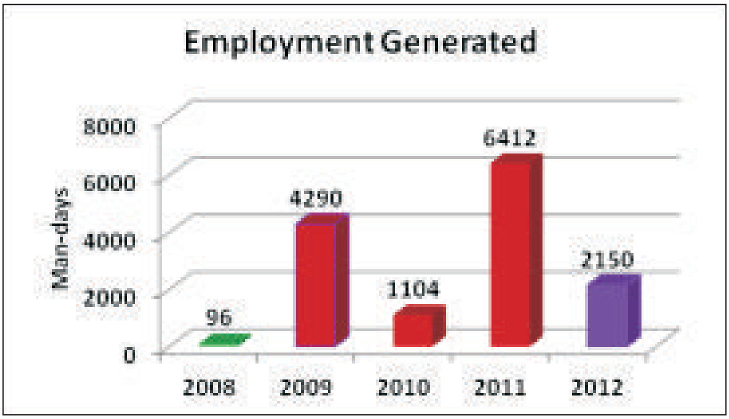


Figure 5.19: Employment generated during the watershed development

5.2.4 Income generating activities for livelihood development

Landless farmers and families hold considerable population (84 families (27%)) of the LPG watershed. To provide seasonal as well as year around income to landless farmers, women and unemployed youths were supported various IGAs in the watershed areas. A total of 221 beneficiaries benefited from these activities. The annual gross income per SHGs varied between ₹14,000/- and ₹40, 000/- (Table 5.5). On an average the annual gross income (AGI) per beneficiary is ₹900/-.

Table 5.5: Details of income generation activities and annual gross returns in the LPG watershed

IGAs	Activity	SHG	Beneficiaries	AGI (₹/Group)
Small entrepreneur system	Tailoring	Gramdevi Swetapadma Mahadevi	33	18,000
Household production system	Pickle and sauce making	Swagatika Budirani Janani	30	30,000
Biomass based rural industry	Mushroom	Gramdevi, Swagtika, Neelabadi	39	35,000
	Honey production	Prayas Brhminbuda Budirani	32	14,000
Dairy activity	Cow rearing	Aakanshya Shanti	20	35,000
Livestock management	Goats	Kalamgam Pritam Neelabadi	36	27,000
	Poultry	Maamangla Janani Sagarika	31	40,000

Photo 5.10: IGAs in the LPG watershed

5.2.5 Community contribution

Contribution of the community towards watershed activities/works is considered as a measure of participation. Moreover, contribution in terms of cash and kind enhances the responsibility and commitment to maintain the works and activities created under the project. People came forward enthusiastically to contribute for private as well as panchayat land in terms of cash and kind showing indication of sustainability of works carried out under the project. A total amount of ₹1,21,252/-has been received as a contribution under various works in the watershed will be utilized in the post project maintenance of the assets created in the watershed.

5.2.6 Convergence activities in the watershed

Watershed management cannot be realized in isolation as it involves different administrative wings of the government. To have an effective watershed management schemes like Rashtriya Krishi Vikas Yojana (RKVY), MGNREGA, Swarnajayanti Gram Swarozgar Yojna (SGSY), Odisha Forestry Sector Development Project (OFSDP) and such other schemes or private players must converge to yield desired results. Need for convergence Substantial public investments are being made for the strengthening of the rural economy and the livelihood base of the poor, especially the marginalized groups like SC/STs and women. In Lachhaputtraghati watershed, following activities was carried out in the convergence of NWDPRA during the implementation period (2008-2012) are given in Table 5.6.

Table 5.6: Activities taken in the watershed under convergence approach

S.No	Activity	Agency or Schemes/ Programme
1	Dugout ponds for water harvesting (Two Numbers)	Block Office, Koraput, Odisha
2	Eucalyptus plantation (15 ha) on private land	BTTL, Jeypore, Koraput District, Odisha
3	Mixed forest plantation (15 ha)	Odisha Forestry Sector Development Project (OFSDP) under Forest Department of Govt. of Odisha
4	Rubber dam for water harvesting	DWM, Bhubaneswar under NAIP
5	Pump sets and pipeline	Agriculture Department

5.2.7 The economic viability of the project

Economic analysis of the project was carried out for the entire watershed (arable and non-arable) by considering the cost and direct benefits from different activities. The productive life of the watershed project was assumed up to 20 years. The BCR at 10 % discount rate is found to be 1:1.16 and IRR is worked out to be 19.5 % of arable lands. This reveals that the BCR and IRR for arable and non-arable lands suggest the economic viability of the project.

5.2.8 Technical man days at different phases of watershed development

The watershed development is an essential technical skill required starting from planning to completion stage of the watershed. The technical man days actually involved in different phases of watershed development has been worked out for the LPG watershed and presented in Figure 5.20. The technical man days at watershed work phase is workout to 2.3 and 3.0 man days ha^{-1} (71% of the total man days) for the total and the treatable area in the watershed, respectively. The technical man days accounts for only 12 and 17% of the total man days ha^{-1} during the preparatory and the consolidation phase of the watershed, respectively. Technical man days slightly higher during the consolidation phase due to completion of pending works coupled with data collection and analysis for impact evaluation.

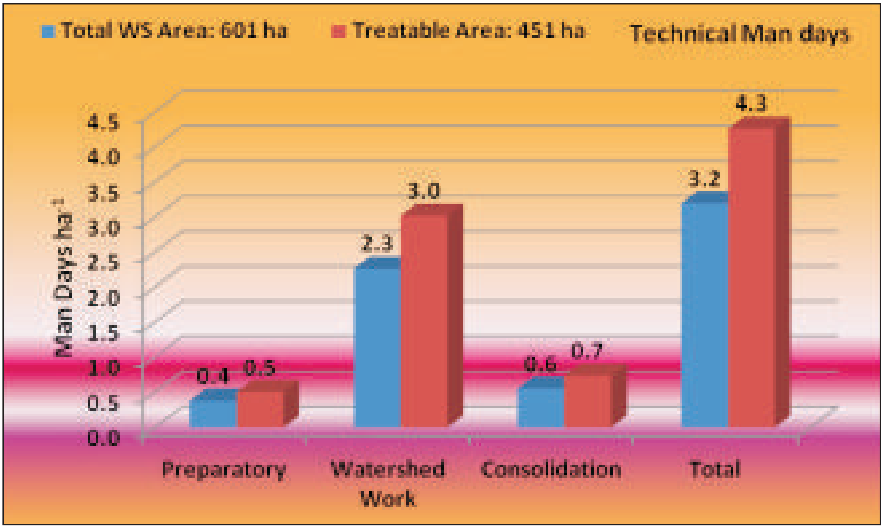


Figure 5.20: Technical man days at different phases of watershed development

6 RECOMMENDATIONS

- Socio-cultural-economics of tribal community to be fully understood and respected in the successful implementation of any project and to get community participation and support.
- Basic amenities still lacking in most of the tribal villages are to be addressed properly through gap filling infrastructure development and convergence approach.
- Community / watershed committee linkage with the development departments are the key factor in holistic and sustainable development of the tribal dominated watersheds.
- *Jhola* is a perennial stream fed intensively cultivated (paddy) area on stream bed and either side of the stream which supports the maximum adult carrying capacity among the major land use. Catchment areas to be treated with soil and water conservation measures and vegetation cover for the sustainable water flow in the *jhola*.
- Assessment of extent of area under jhola supported land use system and their characterization to be carried out in the Eastern Region of Odisha for their development.
- *Bedda* is a gentle sloping land just above the jhola lands potential for high value crops like vegetables during monsoon season. Increasing cropping intensity is possible through water resource development through diversion of jhola water, small scale lift irrigation systems, dugout ponds *etc*.
- Slopping degraded land (*Dunger* land) is potential for agroforestry systems with soil and water conservation measures and water harvesting through silpauline lined ponds for protective irrigation. Major constraint is uncontrolled grazing during the post monsoon season is a bigger threat for successful establishment of plantations. Therefore it's suggested that, cost towards bio-fencing also should be supported by the project for individual land holding.
- The degraded forest lands on high slopes are to be protected and developed through community participation and mechanism of sharing of benefits with the community are to evolved.
- The tribal community still not convinced with use of micro irrigation systems particularly for high value crops. Required further concentrated effort in this direction in order to improve the rainwater use efficiency and productivity.
- Scope for land use diversification and crop diversification in the region with the packaging of conservation and production technologies are to be fully supported by the project or program.
- Hydrological monitoring to be done at least at a micro watershed level in each district along with biophysical and socioeconomic data monitoring for assessing the tangible and intangible benefits of the watershed project by the implementing agency in the region.

7 REFERENCES

Ahluwalia, S. Montek. 2005. Reducing Poverty and Hunger in India: the role of agriculture, annual Report Essay. IFPRI 2004-2005. DOI: http://dx.doi.org/10.2499/0896297519.E02

Alipour, A., Veisi, H., Darijani F., Mirbagheri B. and Behbahani, A.G. 2012. Study and determination of energy consumption to produce conventional rice of the Guilan province. *Res. Agr. Engg.,* 58(3):99-106.

Allen, G.R., Pereira, S.L., Raes, D. and Smith, M. 1998. Crop evapotranspiration: Guidelines for computing crop water requerements. Food and Agrocultural Organization of the United Nations, FAO-56. Rome. 300p.

Brown, S. 1997. Estimating biomass and biomass of tropical forest: a primer. FAO Forestry Paper No. 134, Rome: Food and Agriculture Organization. 55p.

Chauhan, K.P.S. 1998. Framework for conservation and sustainable use of biological diversity. Action plan for the Eastern Ghats Region. The Eastern Ghats, Proceedings of National seminar on Conservation of Eastern Ghats, Andhra University, Vishakapatanam.

Chuang, F.T. 1973. An Analysis of Change of Taiwan's cultivated land utilization in recent years. Rural Economic Division, JCRR Rep. 21, Taipei, Taiwan.

Dass, A., Sudhishri, S., Patnaik, U.S. and Lenka, N.K. 2009. Effect of agronomic management on watershed productivity, impact indices, crop diversification and soil fertility in Eastern Ghats of Orissa. *J. Soil Water Conserv., India,* 8(3):34-42.

Deshpande, R.S. and Ratna Reddy, V. 1991. Differential impact of watershed based technology: Some analytical issues. *Indian J. Agricul. Econ.,* 46(3): 261-269.

Dhyani, B.L., Samra,J.S., Ram Babu and Kumar, N. 2001. Environmental payoff integrated watershed management programme in Garhwal Himalaya- A case study of ORP Fakot. *J. Soil Water Conserv.,* 45(3&4): 141-147.

Gittinger, J.P. 1972. Economic Analysis of Agricultural Projects. The Johns Hopkins University press. Baltimore. 221p.

Gittinger, J.P. 2004. Economic Analysis of Agricultural projects.Economic Development Institute. The World Bank. http:// www.stanford.ed/group/FRI/Indonesia/ document/ gittinger/output/ title.htm.21 1984 2004.

Gundogmus, E. 2006. Energy use on organic farming: a comparative analysis on organic versus conventional apricot production on small holding in Turkey. *Energy Conver. Manage.,* 47:3351-3359.

Jackson, M.L. 1973. Soil Chemical Analysis, Indian ed., New Delhi, Prentice Hall of India. 498p.

Joshi, P.K., Jha, A.K., Wani, S.P., Joshi Laxmi. and Shiyani, R.L. 2005. Meta-analysis to assess impact of watershed program and people's participation. Research Report 8, Comprehensive Assessment of Watershed Management in Agriculture, International Crops Research Institute for the Semi-Arid Tropics and Asian Development Bank, 21p.

Joshi, P.K., PangareVasudha Shiferaw, B., Wani, S.P., Bouma, J. and Scott, C. 2004. Socioeconomic and policy research on watershed management in India: Synthesis of past experiences and needs for future research. Global Theme on Agroecosystems Report no. 7. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. 88p.

Katar Singh. 1992. People's Participation in natural resources management. Workshop Report-8, Institute of Rural Management, Anand, pp7-9.

Lal, R. 2000. Integrated Watershed Management in the Global Ecosystem. Soil and Water Conservation Society of America, CRC Press Boca Raton USA.395p.

Maji, A.K. 2007. Assessment of degradation and wastelands of Indian. *J. Indian Soc. Soil Sci.,* 55(4): 427-435.

Negi, J.D.S., Manhas, R.K. and Chauhan, P.S. 2003. Carbon allocation in different components of some tree species of India: A new approach for carbon estimation, *Curr. Sci.,* 85(11): 1528-1531.

NIN. 2009. Nutrient Requirements and Recommended Dietary Allowances for Indians. A Report of the Expert Group of the Indian Council of Medical Research, National Institute of Nutrition, Indian Council of Medical Research, Hyderabad-500 604, 334p.

NRAA. 2008. Common Guidelines for Watershed Development Projects-2008. National Rainfed Area Authority, Planning Commission, Government of India, New Delhi-110012, 59p.

NRAA. 2011. Challenges of Food Security and its Management 2011. National Rainfed Area Authority, Government of India.

NRAA. 2012. Prioritization of Rainfed Areas in India. National Rainfed Area Authority, Government of India, New Delhi, Study report 4, 100p.

PBIO 100 Lectures Notes. 1999. Lecture 40 World Food Problems. The Undergraduate Program in Plant Biology, University of Maryland.

Rockström, J., Nuhu Hatibu, Theib, Y., Oweis and Wani, S.P. 2007. Managing water in rain-fed agriculture. Pages 315-348 in Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture (ed. David Molden). London, UK: Earthscan and Colombo,Sri-Lanka: International Water Management Institute.

Samra, J.S. 1997. Status of Research on Watershed Management. CSWCRTI, Dehradun, 44p.

Samra, J.S. 1998. Watershed management for sustainable agriculture. In: (Dhaliwal GS, Arora R,Randhawa NS and Dhawan AK., eds) Ecological agriculture and sustainable development, Volume Center for Research in Rural and Industrial Development, Chandigarh, India. pp147-155.

Shah, A. 2001. Who Benefits from Participatory Watershed Development? Lessons from Gujarat, India, IIED Gatekeeper Series 97 IIED, London.

Sharda, V.N., Dogra, P. and Prakash, C. 2010. Assessment of Production Losses Due to Water Erosion in Rainfed Areas of India. *J. Soils Water Conserv.,* 65(2):79-91.

Sharda,V.N., Juyal,G.P. and Naik, B.S. 2008. Watershed Development in India : Status and Perspective. CSWCRTI, 218, Kaulagarh Road, Dehradun-248 195, Uttarakhand. 219p.

Sharda,V.N., Samra, J.S. and Dogra, P. 2005.Participatory watershed management for sustainable development: Experience from IWDP. *India J. Soil Conserv.,* 33(2):93-103.

Sharma, R. 2002. Watershed development adaptation strategy for climate change. Paper presented in South Asia expert workshop on adaptation to climate change for agricultural productivity, organized by the Government of India, UNEP and CGIAR, New Delhi.

Sikka, A.K., Madhu, M., Subhashchand, Selvi., V., Singh, D.V., Sundarambal, P. and Jeevarathanam, K. 2004. Participatory Watershed Management for Sustainable Development in Salaiyur watershed, Coimbatore, Tamil Nadu, CSWCRTI, Research Centre, Udhagamandalam, 96p.

Singh, K.P., Prakash Ved, Srinivas, K. Srivastva, A.K. 2008. Effect of tillage management on energy-use efficiency and economics of soybean (*Glycine max*) based cropping systems under the rainfed conditions in North-West Himalayan region. Soil Tillage Res., 100:78-82.

Singh, P., Vijaya, D., Chinh, N.T., Aroon Pongkanjana, Prasad, K.S., Srinivas, K. and Wani, S.P. 2001. Potential Productivity and Yield Gap of Selected Crops in the Rain-fed Regions of India,Thailand and Vietnam, Natural Resource Management Program Report No. 5., International Crops Research Institute for the Semi-Arid Tropics, Patancheru, India.

Tejwani, K.G., Gupta, S.K. and Mathur, H.N. 1975. Soil and water conservation research 1956-71. Indian Council of Agricultural Research, New Delhi. 358p.

Tuti, M.D., Ved Prakash, Pandey, B.M., Bhattacharyya, R., Mahanta, D. Bisht, J.K., Mukesh Kumar, Mina, B.L., Kumar, N.,Bhatt, J.C. and Srivastva. A.K. 2012. Energy budgeting of colocasia-based corpping systems in the Indian sub-Himalayas. *Energy*, 45:986-993.

Wani, S.P., Singh, H.P., Sreedevi, T.K., Pathak, P., Rego, T.J., Shiferaw, B. and Iyer, S.R. 2003a. Farmer-participatory integrated watershed management: Adarsha Watershed, Kothapally India:An innovative and upscalable approach. Case 7. Pages 123-147 in Research towards integrated natural resources management: examples of research problems, approaches and partnerships in action in the CGIAR (R.R. Harwood and A.H. Kassam. eds.). Interim Science Council and Centre Directors Committee on Integrated Natural Resources Management, Consultative Group on International Agricultural Research, Washington D.C, USA. Rome, Italy: Food and Agriculture Organization.

Wani, S.P., Pathak, P., Jangawad, L.S., Eswaran, H. and Singh, P. 2003b. Improved management of Vertisols in the semi-arid tropics for increased productivity and soil carbon sequestration. Soil Use and Manage., pp 217-222.

Wani, S.P., Pathak, P., Tam, H.M., Ramakrishna, A., Singh, P. and Sreedevi, T.K. 2002. Integrated watershed management for minimizing land degradation and sustaining productivity in Asia, in integrated land management in the dry areas (Zafar Adeel ed), Proceedings of Joint UNU-CAS International Workshop, Beijing, China, Jingu-mae 5-53-70, Shibuya-ku, Tokyo-1508925, United Nations University. pp 207-230.

Wischmeier, W.H. and Smith, D.D. 1960. A universal soil-loss equation to guide conservation farm planning. Trans. Int. Congr. Soil Sci., 7th, pp 418-425.

Wischmeier, W.H. and Smith D.D. 1978. Predicting Rainfall Erosion Losses: A Guide to Conservation Planning. Agriculture Handbook No. 537. USDA Agricultural Science Handbook. Washington, DC 58p.

Wischmeier, W.H., Johnson, C.B. and Cross, B.V. 1971. A soil erodibility nomograph for farmland and construction sites. *J. Soil Water Conserv.,* 26:189-193.

8 ACRONYMS & ABBREVIATIONS

AER	:	Agro-Ecological Region
AET	:	Actual Evapotranspiration
AGI	:	Annual Gross Income
AMC	:	Antecedent Moisture Condition
BCR	:	Benefit Cost Ratio
BDO	:	Block Development Officer
BTTL	:	Bilt Tree Tech. Ltd.
BRGF	:	Backward Regions Grant Fund
CBO	:	Community Based Organization
CDI	:	Crop Diversification Index
CFI	:	Crop Fertilization Index
CLUI	:	Cultivated Land Utilization Index
CN	:	Curve Number
CPI	:	Crop Productivity Index
CPR	:	Common Property Resources
CSWCRTI	:	Central Soil & Water Conservation Research & Training Institute
DARE	:	Department of Agricultural Research and Education
DG	:	Director General
DDG	:	Deputy Director General
DLT	:	Drainage Line Treatment
DoLR	:	Department of Land Resources
DPAP	:	Drought Prone Areas Programme
DPR	:	Detailed Project Report
DWM	:	Directorate of Water Management

EERW	:	Energy Efficiency of Rain Water
EPA	:	Entry Point Activities
FGD	:	Focus Group Discussion
GIS	:	Geographical information System
GO	:	Government Organizations
GOI	:	Government of India
GP	:	Gram Panchayat
HH	:	Household
HPCC	:	Human Population Carryng Capacity
ICAR	:	Indian Council of Agricultural Research
IGA	:	Income Generating Activities
IRR	:	Internal Rate of Returns
IWDP	:	Integrated Wastelands Development Programme
IWDP	:	Integrated Watershed Development Project
IWEI	:	Induced Watershed Eco Index
IWMP	:	Integrated Watershed Management Project
LCC	:	Land Capability Classification
LGP	:	Length of Growing Season
LPG	:	Lachha Putra Ghati
M ha	:	Million Hectares
M	:	Million
MC	:	Micro Catchment
MJ	:	Megha Joules
MGNREGA	:	Mahatma Gandhi National Rural Employment Guarantee Act
MMA	:	Macro Management of Agriculture
MoA	:	Ministry of Agriculture
MoRD	:	Ministry of Rural Development
msl	:	Mean Sea Level
MWS	:	Micro Watershed
NABARD	:	National Bank for Agriculture and Rural Development

NAEB	:	National Afforestation and Eco-development Board
NAIP	:	National Agriculture Innovation Project
NAP	:	National Afforestation Programme
NGO	:	Non Government Organizations
NIN	:	National Institute of Nutrition
NRAA	:	National Rainfed Area Authority
NREGS	:	National Rural Employment Guarantee Scheme
NRM	:	Natural Resource Management
NRSC	:	National Remote Sensing Centre
NWDPRA	:	National Watershed Development Project for Rainfed Areas
OFSDP	:	Odisha Forestry Sector Development Project
OIC	:	Officer- In-Charge
ORP	:	Operational Research Project
OWDM	:	Odisha Watershed Development Mission
P	:	Precipitation
PET	:	Potential Evapotranspiration
PIA	:	Project Implementing Agency
PME	:	Project Monitoring and Evaluation
PPI	:	People's Participation Index
PRA	:	Participatory Rural Appraisal
PSER	:	Potential Soil Erosion Rate
RAPI	:	Rainfed Areas Prioritization Index
RC	:	Research Centre
REY	:	Ragi Equivalent Yield
RKVY	:	Rashtriya Krishi Vikas Yojna
R&D	:	Research & Development
RVP/FPR	:	River Valley Project / Flood Prone River
RWUE	:	Rain Water Use Efficiency
SBI	:	State Bank of India
SC	:	Scheduled Caste

SCB	:	Semi Circular Bund
SFS	:	Social Forestry Scheme
SGSY	:	Swarnajayanti Gram Swarozgar Yojna
SHG	:	Self-Help Group
ST	:	Scheduled Tribe
SWOT	:	Strength Weakness Opportunity and Threat
SWS	:	Sub-Watershed
TDA	:	Total Degraded Area
TGA	:	Total Geographical Area
UG	:	User Group
USD	:	United State Dollar
USLE	:	Universal Soil Loss Equation
VWC	:	Village Watershed Committee
WA	:	Watershed Association
WARASA	:	Watershed Areas Rainfed Agricultural System Approach.
WC	:	Watershed Committee
WD	:	Water Deficit
WDF	:	Watershed Development Fund
WDFA	:	Watershed Development Fund Account
WDPSCA	:	Watershed Development Project for Shifting Cultivation Areas
WDT	:	Watershed Development Team
WHS	:	Water Harvesting Structure
WP	:	Watershed Productivity
WPA	:	Watershed Project Account
WPC	:	Water Productivity of Crop
WS	:	Water Surplus
WSD	:	Watershed Development
WSM	:	Watershed Management

9 SELECTED PHOTOS

Brush wood barriers in the small gullies

Pigeon pea & pineapple on field bunds

Shri Mohapatra, ED, NALCO, Damanjodi during the inauguration of IGAs

Gully control structure

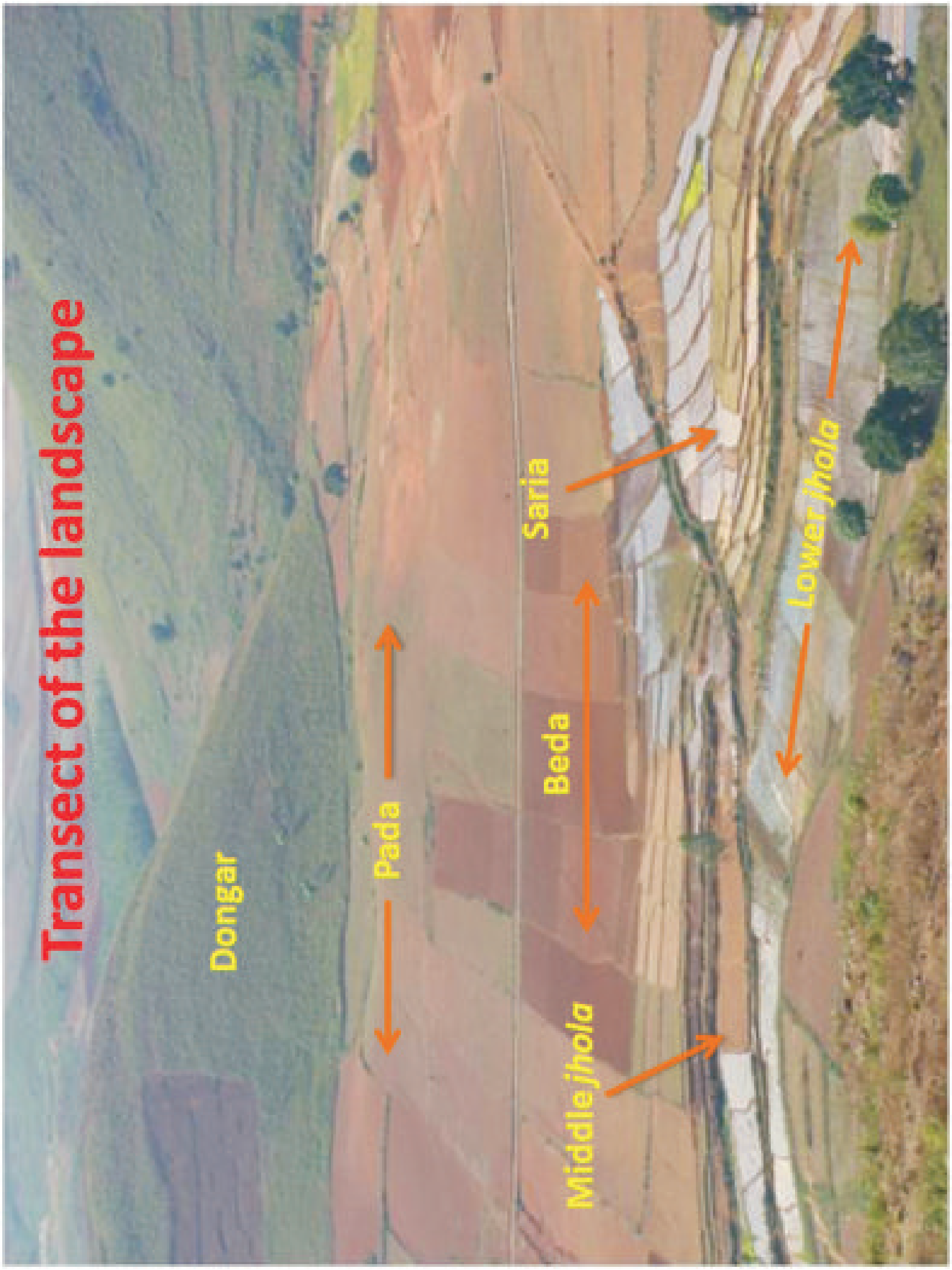
Farm ponds for rainwater harvesting

Agri-Horticulture: Pineapple on circular bund

Apiculture under IGAs

Jhola kundi with krishak bandhu pump

ANNEXURE


Transect of the landscape
Dongar
Pada
Beda
Saria
Middle jhola
Lower jhola

General transect analysis of LachhaputtraghatiWatershed

Slope along different divisions **Particulars**	***Dongar***	***Padda***	***Ghar***	***Beda***	***Saria***	***Jhola***
ALTITUDE (m)	1200-1300	990-1200	950-990	900-950	870-900	850-870
SLOPE (%)	100-150	70-80	20-25	10-12	5-8	1-3
LANDUSE	Scrub forest	Shifting cultivation	Habitation	Vegetables	Upland cultivation	Lowland cultivation
CROPS	Niger	Niger, Ragi	Beans, Banana (Kitchen garden)	Tomato, Ginger	Rainfed paddy, Arhar	*Jhola*Paddy
LIVESTOCK	Open grazing area	Open grazing area	Buffalo, cattles, backyard poultry	Goats, pigs	-	Fish
WATER AVIALABLITY	Rainfed, high runoff	High runoff	Drinking water supply through pipeline using gravity	Scarcity for horticulture and plantations	Water scarcity in lean period	Perennial flow of water with poor management
PROBLEM (S)	Land degradation and shifting cultivation, High erosion rates	High runoff and Gully erosion	Low productivity, Post- monsoon water scarcity High mortality and low productivity of livestock	Low productivity, Open grazing,	High soil loss, poor water management	Flooding in rainy season, bund breaching, low productivity
PRODUCTION POTENTIAL	Silvipastoral	Horticulture with grasses	Small and Microenterprise (Mushroom, Apiculture, Goatry)	Agroforestry Farm pond, Agri-hort. system	Conservation Agronomy practices	Intensive agriculture
OPPORTUNITIES	Silvipastoral system with Stone bunding, trenching for*in-situ*moisture conservation and ground water recharge	Fruit tree plantation Staggered contour trenching and recharge pits	Artificial insemination Improved poultry breeds Vermicomposting	Scope of Biofuel and orchards Pisiculture	Intercropping, strip cropping, contour farming	System of rice intensification, Sambuta grass plantation to control bund breaching

Dr A.K. Sikka, DDG (NRM) & Dr P.K. Mishra, Director with the ICAR Awards -2013
Awardees from CSWCRTI