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Methodology for evaluating livelihood security of farm households in treated watersheds

Kaushalya Ramachandran*[1]*, U.K. Mandal, K.L. Sharma, M. Gayatri, V. Bhaskar, K. Venkatravamma and P. Kartik

Central Research Institute for Dryland Agriculture (ICAR), Santoshnagar, Hyderabad - 500059

ABSTRACT : Watershed-based development in India has been the strategy for growth and sustainability of agriculture in semi-arid and dry sub-humid regions. Large public investments have been assigned for the purpose in the last 25 years with little tangible results as stated by Planning Commission of India (2005) and more investments are earmarked for this purpose. Approaches to watershed development and management differ notwithstanding guidelines for a common approach, often resulting in lopsided development that renders comparison of gains achieved in any two watersheds, unrealistic. In view of the importance of watershed program for development of rainfed regions in India, a study was undertaken to evaluate livelihood security of farm households using multi-disciplinary tools and techniques. Sustainability indicators were constructed to evaluate livelihood security at household level in four treated micro-watersheds in four villages located in Telangana region of Andhra Pradesh identified as agro-ecological sub-region (AESR) 7.2. The methodology developed under this study facilitates a quantitative evaluation of impact of watershed projects in the region. Study indicates that to achieve livelihood security, watershed development program must emphasis on two issues - increasing yield and income. The indicators useful for evaluating these two issues were identified as development of sources of irrigation, soil OC content and fertility status, adoption rate of improved land management practices, slope management, S&WC measures, etc. In order to convert these intangible aspects of agricultural management into tangible results, institutional support by way of increasing access to institutional credit and mobilizing farmers to form associations that could take care of their interests, were found to be vital. The present paper illustrates the methodology developed to evaluate livelihood security in two micro-watersheds in a village called Pamana located in Rangareddy District of Andhra Pradesh.

Key words : Monitoring and Evaluation. Rainfed agriculture; Sustainability indicators; Watershed development; GIS

The semi-arid, hot dry and moist sub-humid regions of Peninsular India, extends over 76.74 million ha in the states of Andhra Pradesh, Maharashtra, Karnataka and Tamilnadu. In this rainfed region, watershed-based development has been an important component of economic development planning to ensure sustained agricultural productivity, livelihood security and enhancement of rural lifestyle. According to census of India (Govt. of India, 2001), over 71 million persons are involved in agriculture and allied activities in these states alone. Thus, development of agriculture is crucial for safeguarding the interests of rain- dependant farming community where average annual rainfall of 500 to 700 mm occurs in 28 to 40 rainy days in the form of rainstorms. Such intensive rainfall events also induce severe soil erosion, as land is usually barren or sparsely vegetated at this time of the year.

Despite the importance of watershed development programme (WDP), it was inefficiently implemented by multiple agencies involving large-scale misuse of funds as noted by X Five-Year Plan (FYP) Mid-term Appraisal Report (Planning Commission, 2005). Under Eleventh plan, Govt. of India has allocated a sum of Rs. 15359.46 crore (at 2006-2007 prices), for development of watershed projects under Drought-prone Area Development Program (DPAP), Desert Development Program (DDP) and Integrated Watershed Development Program (IWDP) besides a special package of Rs. 300.61 crore earmarked for the 31 suicide- prone districts in Andhra Pradesh (AP), Maharashtra, Karnataka and Kerala, a new Rainfed Area Development Programme with Rs. 3500 crore and Rs. 58860.55 crore for central and state planning schemes (Planning Commission, Govt. of India, 2008a). These allocations were necessitated due to the distress prevalent in agriculture and allied sectors across the country. In Andhra Pradesh dominance of agriculture sector has declined as is evident from the growth rate of Net State Domestic Product (NSDP) from agriculture during two phases 1984-85 to 1995-96 and 1995-96 to 2004-05 which indicated a decline from 3.18 to 2.69 (NAS - CSO, 2008). Since 2005-2006, Govt. of AP had proposed to treat large area with Watershed Development Programme (WDP) under National Watershed Development Program for Rainfed Areas (NWDPRA) programme. In 2008-

2009 it is proposed to treat over 19000 ha with an outlay of Rs. 11.40 crore (DoA, 2008), indicating a growing concern to make WDP more effective than before in the state.

Several studies have been undertaken to evaluate WDP as individual case studies (Sreedevi *et al.* 2004; Kaushalya *et al.* 2007) or reviewed collectively as a program in the country (Samra, 1997, Farrington *et al.* 1999; Samra *et al.* 2000; Kerr, J. *et al.* 2002; Hanumantha Rao, 2000; Joshi, P.K *et al.* 2005). Besides these, a few studies have also been undertaken to review government policies with regard to WDP in states like Andhra Pradesh (Oliver Springate - Baginski *et al.* 2004) and on cost of resource degradation like groundwater exploitation (Ratna Reddy, 2003). All these studies have noted that the WDP has yielded low returns despite large investments. The Eighth, Ninth and Tenth FYP have focused on improving the program and mid-term reviews and Planning Commission's Working Group on Watershed Development, Rainfed Farming and Natural Resources Management for the Tenth FYP (2001) and Mid-term Appraisal of Tenth FYP (Planning Commission, 2005) have deliberated on these issue. As a result, the guidelines of WDP have been revised several times since 2000 and the latest revision came into effect from April 2008.

In view of the importance of WDP for reviving and sustaining rainfed agriculture, a study was undertaken to evaluate a few watershed projects that were initiated in the semi-arid tract in Telengana region in AP during 1998 - 2000, in order to, identify factors that caused low returns from WDP. A multidisciplinary study was undertaken using conventional and modern geo-informatics techniques to evaluate watershed projects implemented by various agencies like Dept of Agriculture, Govt. of Andhra Pradesh, research organizations like CRIDA, MANAGE and an NGO called Deccan Development Society based at Hyderabad. The objective of the study was to develop a methodology to evaluate impact of WDP on sustainable development of rainfed agriculture for five aspects of sustainability namely, *productivity, security, protection, viability* and *social acceptability* at three spatial levels-household, field and watershed level. The present paper describes the evaluation methodology developed for assuring *livelihood security* at household-level in a treated micro-watershed in a village named Pamana, which is located at a distance of 65 km to the southwest of Hyderabad Urban Agglomeration. The methodology developed would support an independent third - party evaluation of the WDP after departure of the Project Implementing Agency (PIA) from the scene. Usually such evaluation is difficult without reliable geo-referenced pre-project baseline data pertaining to soil fertility levels, location of S&WC structures, NDVI status, crop cafeteria, yield level data, etc.

In order to find solution for such a problem, [a research program was launched in CRIDA under the National Fellow Scheme awarded to the first author in February 2005], attempts were made to develop a methodology for evaluation of WDP using GIS, DGPS and high-resolution satellite data along with use of conventional methods of evaluation like soil analysis and socio-economic survey. Under the research program, a multidisciplinary quantitative methodology has been evolved for initiating evaluation of WDP (Ramachandran *et al.*, 2007) to ensure an independent evaluation of WDP that is not affected by scale, site, location, period and PIA-related restrictions; it is objective, quantifiable and replicable as can be seen from the study reported in this paper. The method was applied in eight micro-watersheds - four treated and four untreated and the results of evaluation of livelihood security of farmers in one treated micro-watershed in Pamana village located in Chevella Mandal, Rangareddy District of Andhra Pradesh, has been presented in this paper.

MATERIALS AND METHODS

To develop such a methodology of evaluation, a large volume of data was required to be generated through primary collection, secondary collation, deduction, GIS analysis, satellite data interpretation and field visits. The material and methods used for the study can be grouped under two distinct heads: the first one pertaining to data collection and development of analytical procedure and the second one pertaining to application of methodology to an experimental watershed.

Data collection and analytical procedures

GIS and remote sensing techniques were used to supplement information generated during actual field survey carried out using DGPS and to a limited extent by a Total Station. Soil quality was analysed for twelve physico-chemical and biological properties namely, pH, EC, CEC, OC, major nutrients - N, P, K, micro-nutrients - Zn, Cu, Fe and Mn and microbial biomass (MPC) and dehydrogenase assay.

A socio-economic survey was conducted in the selected watersheds using two structured questionnaires for household - level and field, watershed / village - level data collection. Economic analysis included calculation of net income, input costs, net returns from farming activities, and equity distribution in the watersheds for which *Gini-*coefficient was calculated. A watershed database was created in MS-Access and thematic maps were drawn using ArcGIS (v. 9.0) to construct some of the sustainability indicators.

Experimental watersheds

Although the study area extended over eight micro-watersheds covering 731.44 ha, the present paper describes the study undertaken in only two micro-watersheds -one treated and another untreated in Pamana village located in Chevella Mandal in Rangareddy District of Andhra Pradesh. Chevella Watershed had been developed under the Model Watershed Program in 1985. During 1999-2000 Govt. of Andhra Pradesh developed two micro-watersheds in Pamana village under the Drought-prone Area Program (DPAP). The village is located at 78°7'30"E & 17°16'45"N and forms a part of the Himayatsagar basin. Under the DPAP program, ten check-dams were constructed within the catchments of a 1st order stream in the village called micro-watersheds for this study. The WDP was implemented by the Dept. of Agriculture, Govt. of AP and a *Watershed Committee* was formed consisting of primary stakeholder belonging to the respective watersheds. Seed money was sanctioned to the village administration (*Gram Panchayat*) and the Dept. of Agriculture provided technical support for development of watersheds in the village.

Methodology

To undertake evaluation of WDP, a reconnaissance survey was conducted in both micro-watersheds to identify core issues that affected rainfed agriculture. The issues identified were farmer's satisfaction, resource conservation and watershed development- related activities for which sustainability indicators were constructed to assess their impact on livelihood security at household level in the village. In order to develop a quantifiable evaluation methodology, a scorecard was generated for all parameters pertaining to these three issues for which relevant indicators were constructed (Table 1). Simple statistical techniques like averages, weightage - for signifying relative importance, and threshold value, etc., were used to assign values for the parameters. In the event of absence of data pertaining to immediate post-WDP period, a baseline was generated with threshold value for each parameter assuming a 20% improvement over community average presuming a positive impact of WDP. Use of 20% over average as threshold value was assumed based on two leading studies, one by Gomez *et al* (1996) for evaluating sustainable development at farm level; and another by Joshi *et al* (2005) on evaluation of WDP in India. While in the former study, the authors used 20% increment over community average as threshold for evaluating sustainability of land management practices at farm level in Guba, Cebu in Philippines, in the second study on a meta-analysis for assessment of impact of watershed programs in India by Joshi *et al* (2005), three hundred and eleven watershed projects were evaluated and an internal rate of return of 22% was reported with a benefit-cost ratio of 2.14. Keeping in view these two studies, it was assumed that a modest 20% improvement over community average could be considered a rational and acceptable rate of gain after conclusion of WDP by the PIA. Hence, a baseline of post-WDP period was generated using the threshold value as mentioned earlier.

For evaluating sustainability of livelihood security achieved through WDP in Pamana village, 180 farm households were interviewed and socio-economic data was collected using structured questionnaires to generate a baseline for various sustainability indicators. Over 120 soil samples were collected and analysed for determining soil fertility status based on the twelve physico-chemical and biological parameters. The study was anchored on the principle of '*Five pillars of Sustainability*' (FAO 1993; Smyth and Dumanski, 1995; Gomez *et al.* 1996; Swete Kelley and Gomez, 1998) and in the present paper only one aspect of sustainability pertaining to livelihood security has been discussed.

Twelve indicators were constructed for assessing the three core issues that impact sustainability of livelihood security at household-level in treated micro-watersheds. One of the issue that pertains to farmer's satisfaction was evaluated using the following indicators namely, increase in yield level, income and availability of irrigation water. To assess the issue of efficacy of resource conservation measures undertaken by farmers, the indicators constructed were: soil OC, soil fertility, farm size and slope of land. For evaluating the third issue namely WDP activities, the indicators constructed were: income generating capacity, implementation of improved land

Table 1. *Sustainability Indicators used for evaluation of Household Livelihood Security under WDP*

Sustainability Indicators	Source of data	Method of analysis	Score	Threshold value	Remarks
1. Farmer's Satisfaction					
Yield gain from potential yield	*Primary data (Survey)*	Yield gain =((Actual threshold yield) (Potential yield)) *100 =((A / (A +20% of A))/ (I / (? + 20% of ?)) *100 *(Indicated in methodology Table 2a)*	Crop weightage based on dietary requirement (kcal) Pulses & cereals-4 Oil seeds - 3 Commercial crops-2 Vegetables - 1	100%	A= Weighted actual yield of a farm household A = Mean of weighted actual yield I = Weighted district yield A = Mean of weighted district yield Threshold value = Mean + 20% of mean
Net income include	*Primary data (Survey)*	Income from agricultural activity (Rs. capita^{-1} day^{-1})		(USD 2)	Rs. 100 Net income or household income sum of economic value of agricultural produce, income from livestock and wages for labour work undertaken from which input costs are deducted. - Human Development Index (1994, 1999)
Irrigation water availability	*Primary data (Survey)*	(a) By quantity Not available Inadequate Adequate (b) By source Rainfed Bore well Dug well Tank	 0 - unsustainable 1 - moderate 2 - high 0 -unsustainable 1 -low 2 -moderate 3 -high	Max. Score 5	Maximum score possible by adding scores based on availability of irrigation water by quantity and by source. The aim is to encourage water harvesting rather than exploit groundwater.
2. Resource Conservation					
Soil OC content	*Soil survey & analysis*	Actual data <0.1 -0.5 0.5 - 1 1-3	 1-extreme limitation 2-severe limitation 3-moderate limitation	Max. Score-3	Maximum possible score.
Soil fertility status	*Soil survey & analysis*	Available N (kg/ha) <280 281 - 560 >560 Available P (kg/ha) < 10 11 - 25 >25 Available K (kg/ha) < 120 120 - 280 >280	 1 -low 2 - moderate 3 -high 1 - low 2 - moderate 3 - high 1 - low 2 - moderate 3 - high	Max. Score-9	Maximum possible score for a soil having high NPK level as no external input would be required. Source: Ratings for soil test values of primary nutrients (Dhyan Singh, P.K. Chhonkar & R.N. Pandey: Soil plant water analysis-a methods manual: IARI pg. 53)
Slope of land	*RS (temporal data), GIS*	Slope (%) >9 >5 to < 8 >3 to < 5 1 to 3	 1 - unsustainable 2 - low sustainable 3 - moderately sustainable 4 - highly sustainable	Max. Score-4	Maximum possible score.
Farm size	*Land records / Socio -eco survey (primary data)*	Area (ha)		4 ha	B:C ratio of 3.03 among medium category farmers having 4-10 ha landholding found during socio-economic survey conducted in the village.
3. Watershed Development Process					
Land mgmt. practice	*Field survey & interview*	*Types of application -* No organic matter, fertilizer & FYM No organic matter, only fertilizer	 0 - unsustainable	Max. Score-4 1 - low	Maximum possible score. Low use of chemical fertilizers and higher use of organic matter & FYM is advocated

		Low organic matter & high fertilizer	2 - medium		for sustainable agriculture., eg., LEISA.
		Practice of incorporation of organic matter & low fertilizer use	3 - sustainable		
		Practicing mulching, organic matter incorporation, vermin-compost, FYM, agro-forestry plantation, etc.	4 - highly sustainable		
S&WC measures	*Field survey & interview*	None	0 - unsustainable	Max. Score-4	Maximum possible score.
		Check dam (CD)	1-low		Concrete structures like CD has been given low score and an integrated approach has been provided higher score.
		Stony weirs(SW),CD	2-medium		
		Contour trench (CT) contour bund (CB), SW, CD	3-sustainable		
		Conservation tillage, live barriers, contour bunds, continuous contour trench (CCT), SW, grassing of water ways, key-line plant-ation, CD	4-highly sustainable		
Membership of Farmers' Assoc.	*Socio-eco survey & Interview*	If no participation	0 - unsustainable	Max. Score -1	Maximum possible score.
		If yes (active participation)	1- moderate		
Credit availability	*Socio-eco survey & Interview*	Local money lender/poor farmer	0 - unsustainable	Max. Score-3	Maximum possible score. Dependence on moneylender has proved a bane. Public sector banks ask for collateral for disbursing loan. Cooperatives have been useful at certain cases but SHG have proved the best in AP.
		Public-sector bank	1 - low		
		Co-operative society	2 - medium		
		Self-Help Group (SHG) / Self finance	3 - high		
Institutional support	*Socio-eco survey & Interview*	None	0 - unsustainable	Max. Score -1	Maximum possible score.
		Yes	1 - sustainable		

management practices, S&WC measures, membership to farmers' association, availability of institutional credit and institutional support like services of extension workers, etc (Table 1). Out of the twelve indicators listed in Table 1, five indicators namely - crop yield, soil OC content, soil fertility status, farm holding size and income provided actual quantifiable data; the rest could be measured only qualitatively. Net income or household income in this case included aggregate of economic value of agricultural produce, income from livestock and wages for labour work undertaken; input cost was subtracted from the total return accrued from agriculture. Input cost was calculated according to Cost A definition.

In order to make the whole evaluation procedure quantifiable, a scorecard was developed as indicated in Table 1 with scores and weightage for the indicators, namely- availability of irrigation water, slope of land, S&WC measure, land management practices, membership of farmers associations, availability of credit and institutional support. Higher weight was provided for options that gave better and desirable results for achieving sustainable development. For instance, in case of an indicator, irrigation water availability, a high score of '2' was given to the option denoting 'adequate availability', while a low score of '0' was provided to the option termed 'non - availability of water'. In another case, for instance, for soil OC content, a score or weight of '3' was provided to the option termed 'moderate limitation' while a score of '1' was provided to the option termed 'extreme limitation'. Thus, higher weights were given to options that would presumably ensure sustainable development in the micro-watersheds.

The algorithm for assessing impact of WDP on livelihood security at household level in the micro-watershed is as follows:

Step 1: Identification and construction of relevant indicators for assessing *livelihood security* at farm household-level. Table 1 presents the indicators, their description and threshold values.

Step 2: Three issues that would help in determining sustainability of livelihood security are - *farmers' satisfaction, resource conservation* and *watershed activities*. In order to assess farmer's satisfaction level, three indicators were constructed, namely *yield gain, income* and *availability of irrigation water* (Table 1). To calculate *Yield Gain* from *Potential Yield* (%) the following method was followed:

(1) Actual crop - wise yield was weighted (Table 1) and aggregated to get *Total Weighted Actual Yield.*

(2) District crop -wise yield was weighted similarly and aggregated to get *Total Weighted District Yield.*

(3) *Total Weighted Actual Yield* (A) was averaged to generate *threshold value* or baseline actual yield in the field in treated watershed when PIA departed. (Threshold value is defined as Avg. (Σ Total weighted actual yield) + 20% of Avg. (Gomez *et al.* 1996).

i.e., Threshold value = A +20% of A

(4) *Total Weighted District Yield* (I) was averaged to generate *threshold value* or baseline yield in the district when WDP concluded. Definition of threshold value is same as indicated in *Step 2 (3).*

i.e., Threshold value = I + 20% of I

(5) *Weighted Total Actual Yield / Threshold Total Actual Weighted Yield = Actual Threshold*

(6) *Weighted Total District Yield / Threshold for District Weighted Yield = District Threshold*

(7) *Yield Gain from Potential Yield = Gain from Actual Threshold /District Threshold *100*

Step 3: Income was defined as economic returns accruing from agriculture or income from land holding, wages from agricultural labour within the village, and returns from livestock. Threshold value for income was assumed as Rs. 100/- or US $2 as recommended by Human Development Index (UNDP, 2007). Irrigation water availability was assessed through qualitative information for which scores were provided. Maximum possible score for *irrigation water availability* was assumed as threshold value of the indicator.

Step 4: The issue of resource conservation was assessed through four indicators namely - *soil OC, soil fertility, slope of land* and *farm size*. While soil OC and soil fertility data were based on soil analysis information, a scorecard was developed to grade them and make the data amenable for the evaluation study. Maximum possible score under each of this aspect was assumed as the threshold. Slope information was generated through field survey and scores were provided. Based on LCC principle, lower slope were given higher scores and threshold value determined based on this score. Threshold level for optimum farm size was taken as 4 ha based on B: C ratio calculated for 41 farmers from TMW in Pamana (Kaushalya Ramachandran *et al.*, 2006). Long-term studies on participatory farming systems in *Alfisols* in Telangana region undertaken by CRIDA, indicates a B: C ratio of 1.89 to 2.18 among marginal farmers and 1.39 to 1.88 among small farmers corroborating our findings at Pamana village (CRIDA, 2007).

Step 5: For evaluating watershed development program - *land management practices, S&WC measures, membership of associations, credit availability* and *institutional support* etc., were considered as indicators and accordingly used for analysis. Measurable indicators were quantified while qualitative indicators were provided scores and analysis was undertaken accordingly.

Step 6: The indicators pertaining to the three issues were first aggregated theme-wise. Subsequently, these three indices are added to together to arrive at a Composite Index that is assumed to be the measure of sustainability for evaluating *livelihood security* under WDP. Composite Score which is higher than the threshold value or >1, is considered the boundary between sustainable and unsustainable livelihood security. In a similar manner other aspects of sustainability, namely, *productivity, viability, protection* and *acceptability* can also be analyzed.

Step 7: The results of this analysis can be depicted using a *cobweb* diagram. The level of achievement against each indicator and the threshold limit for that particular indicator can be drawn on one spike of the web diagram; similarly other indicators relevant to the aspect can be depicted in the same diagram. Such a diagram can easily indicate which aspects of a WDP program have been implemented satisfactorily for achieving sustainable *livelihood security* and which aspects are weak-links in the WDP program.

RESULTS & DISCUSSION

Net income accrued to farmers in the treated micro-

Table 2a: *Evaluating sustainability at household- level in TMW*

Household Index (Id)	Farm household no.	Cropping season	Yield (t/ha) Cereals (wt. 4) Actual	District level	Wt actual (4*actual yield)	Wt. dist (4*district yield)	Oil seeds (wt. 3) Actual	District level	Wt. actual (3*actual yield)	Wt. dist (3*district yield)	Vegetables (wt. 1) Actual	District level	Wt. actual (1*actual yield)	Wt. dist (1*district yield)
1	2	3	4				5				6			
AP06PM01255/E2	1	K, R	3.00	0.63	12.00	2.52					21.50	38.61	21.50	38.61
AP06PM02242/36	2	K	0.00	1.03	0.00	4.12								
AP06PM03258/e	3	K									17.31	12.85	17.31	12.85
AP06PM04238/A	4	K, R									37.50	38.57	37.50	38.57
AP06PM05238E	5	K	2.50	3.75	10.00	15.00								
AP06PM07242/35	6	K	0.00	1.03	0.00	4.12								
AP06PM08248A	7	K	2.89	3.75	11.56	15.00	0.50	0.71	1.50	2.13	15.00	12.85	15.00	12.85
AP06PM09295a	8	K, R, S	1.00	0.64	4.00	2.56					13.00	25.69	13.00	25.69
AP06PM10258/a	9	K, R	9.50	4.97	38.00	19.88					15.50	26.14	15.50	26.14
AP06PM11242/30	10	K									0.12	12.85	0.12	12.85

Yield (t/ha) Pulses (wt. 4) Actual	District level	Wt actual (4*actual yield)	Wt. dist (4*district yield)	Commercial crops (wt.2) Actual	District level	Wt. actual (2*actual yield)	Wt. dist (2*district yield)	Total yield (t/ha) Actual	District level	Wt. actual	Wt. dist	from potential yield: Actual thres hold yield (wt actual yiel/threshold	Potential yield (wt dist yield/ threshold	Yield gain from potential yield (%)
7				8				9	10	11	12	13=(11/ Threshold of 11)	14=(12/ Threshold of 12)	15=13/ 14
								24.50	39.24	33.50	41.13	1.12	1.34	83.54
0.25	0.59	1.00	2.36					0.25	1.62	1.00	6.48	0.03	0.21	15.83
								17.31	12.85	17.31	12.85	0.58	0.42	138.17
				25.00	4.67	50.00	9.34	62.50	43.24	87.50	47.91	2.92	1.56	187.32
								2.50	3.75	10.00	15.00	0.33	0.49	68.38
0.08	0.59	0.33	2.36					0.08	1.62	0.33	6.48	0.01	0.21	5.22
								18.39	17.31	28.06	29.98	0.94	0.97	96.00
				0.75	4.67	1.50	9.34	14.75	31.00	18.50	37.59	0.62	1.22	50.48
								25.00	31.11	53.50	46.02	1.78	1.50	119.24
								0.12	12.85	0.12	12.85	0.00	0.42	0.96
								Average	24.98	25.63				
								Threshold=(Avg. + 20% of Avg.)	29.98	30.75				

Assumptions: Weightage to crop types provided, based on importance of crop to human being Threshold value assumed as minimum possible yield gain accrued to farmers on successful completion of WDP. A 20% yield gain was assumed in post-WDP Period compared to ante-WDP period. This assumption was necessary in the event of absence of ante- and post -project yield data for determining baseline. Potential yield defined as district weighted yield.

Col. 1: Unique Index code for each farm household, e.g., P06PM01255/E2, AP - Andhra Pradesh, 06 - year data collection, PM - Pamana village, 01 - serial no., 255/E2 - landholding survey no. Col. 2 : Household no., Col. 3: Cropping season - K - Kharif, R - Rabi, S - Summer Col. 4: Cereals - paddy, maize, sorghum, wheat (Weightage = 4) Col. 5: Oil seeds - sunflower, safflower (Weightage = 3) Col. 6: Vegetables - Carrot, Tomato, Leafy vegetable, Broad bean (Weight = 1) Col. 7: Pulses - pigeon pea, chick pea (Weightage = 4) Col. 8: Non-edible commercial crops - cotton (Weightage = 1) Col. 9: Sum of actual yield (cereals, oil seeds, vegetables, pulses, commercial crops) Col. 10: Sum of district level yield (cereals, oil seeds, vegetables, pulses, commercial crops) Col. 11: Sum of weighted actual yield (cereals, oil seeds, vegetables, pulses, commercial crops)Col. 12: Sum of weighted district-level yield (cereals, oil seeds, vegetables, pulses, commercial crops) Col. 13: Actual threshold value (Wt. actual/ threshold) Col. 14: District /potential yield threshold value (Wt. dist/ threshold) Col. 15: Yield gain from potential yield (%).

Table 2b. *Aggregate information of yield level from 186 farm holdings from TMW & UTMW in Pamana*

	TMW			UTMW			
Average yield (kg/ha)	Max.	Min.	SD	Average	Max.	Min.	SD
Cereals (maize, paddy, sorghum, wheat) - 1414	6500 (maize)	125	2080	654	3750 (maize, sorghum)	125	1176
Oil seeds (castor, sunflower) - 26	1000 (sunflower)	250	131	14	500 (castor)	250	76
Vegetables (carrot, cabbage, chilli, Cucumber, beetroot, tomato) - 3207	17500(carrot)	117	4915	1549	8750 (tomato, carrot)	100	2743
Pulses (pigeon pea, chick pea)-30	833 (pigeon pea)	50	153	107	1250 (pigeon pea)	18	355
Non-edible commercial crops (cotton) - 957	8750 (cotton)	379	2741	859	3750 (cotton)	152	1444

District average yield of major crops (kg/ha): maize-2719, sorghum-1029, carrot-12846, pigeon pea - 585, sunflower - 714, castor - 459, tomato - 12881, cotton - 853

Table 3a. *Generating threshold value for constructing baseline for post-WDP scenario*

Sustainability Indicators for evaluating livelihood security in treated micro-watershed												
Farm household no.	*Farmer's satisfaction* Yield gain from potential yield (%)	Net income (Rs.capita^{-1} day^{-1})	Resource conservation Irri. water avail-ability (Score)	Soil OC content (Score)	Soil fertility status (Score)	Slope of land (Score)	Farm size (ha)	Land mgmt. prac. (Score)	S&WC meas. (Score)	Watershed development process Membership farmer assoc. (Score)	Credit availability (Score)	Inst. support (Score)
1	2	3	4	5	6	7	8	9	10	11	12	13
1	83.54	14.46	2	2	6	2	0.60	0	1	1	0	1
2	15.83	8.41	0	2	4	1	0.40	4	3	1	2	1
3	138.17	61.86	2	2	6	2	0.52	1	2	0	2	0
4	187.32	100.38	2	2	4	2	1.00	0	2	1	1	1
5	68.38	9.64	2	2	4	2	2.03	1	2	0	2	0
6	5.22	8.43	0	2	4	1	2.60	1	2	0	0	0
7	96.00	38.34	2	1	5	2	2.72	0	2	1	2	1
8	50.48	77.57	4	2	6	2	0.92	1	1	0	2	1
9	119.24	15.40	3	2	6	2	1.60	0	4	1	2	1
10	0.96	0.44	0	2	4	1	2.51	0	1	1	2	1
Threshold	100.00	100.00	5	3	9	4	4	4	4	1	3	1

Threshold values are as indicated in Table 1.

Table 3b. *Aggregate information of 186 farm holding from TMW & UTMW in Pamana*

Item	TMW				UTMW			
	Average	Max.	Min.	SD	Average	Max.	Min.	SD
Land holding area (ha)	1.82	9.50	0.03	1.90	2.09	10.37	0.14	2.06
Net income (Rs. capita^{-1} day^{-1})	28.42	193.24	-5.78	31.80	35.37	140.66	-0.66	31.53

Table 4. *Measuring change in livelihood security from ante-WDP scenario at household- level in TMW*

Farmers' satisfaction			Resource conservation			Watershed development process						
Farm household no.	Yield gain from pot. yield	Net income	Avail irr. water	Soil OC	Soil fertility	Slope	Farm holding size	Land mgmt. practices	S&WC measu.	Membership of farmer assoc.	Credit availability	Inst. support
1	2	3	4	5	6	7	8	9	10	11	12	13
1	0.84	0.14	0.40	0.35	0.67	0.5	0.15	0	0.25	1	0.00	1
2	0.16	0.08	0.00	0.33	0.44	0.25	0.10	1	0.75	1	0.67	1
3	1.38	0.62	0.40	0.53	0.67	0.5	0.13	0.25	0.5	0	0.67	0
4	1.87	1.00	0.40	0.35	0.44	0.5	0.25	0	0.5	1	0.33	1
5	0.68	0.10	0.40	0.35	0.44	0.5	0.51	0.25	0.5	0	0.67	0
6	0.05	0.08	0.00	0.33	0.44	0.25	0.65	0.25	0.5	0	0.00	0
7	0.96	0.38	0.40	0.25	0.56	0.5	0.68	0	0.5	1	0.67	1
8	0.50	0.78	0.80	0.51	0.67	0.5	0.23	0.25	0.25	0	0.67	1
9	1.19	0.15	0.60	0.53	0.67	0.5	0.40	0	1	1	0.67	1
10	0.01	0.00	0.00	0.33	0.44	0.25	0.63	0	0.25	1	0.67	1

Values of respective indicators have been derived from Table 3a as follows: Actual value from corresponding cell in Table 3a / respective threshold value watershed (TMW) was compared with the income norm for agricultural labour in Andhra Pradesh, i.e., Rs. 45/- to 96/- per capita / day in 2006. The algorithm discussed in the earlier section was applied for each indicator as given in Table 2b, 3a, 3b & 4 to generate a Composite Index presented in Table 5 to evaluate impact of WDP on *livelihood security* in the TMW. Table 5 indicates the aggregate index values accrued to ten farm households in the TMW in Pamana under the three issues evaluated for assessing impact on *livelihood security*. The Composite

Table 5. *Contribution of WDP in achieving Livelihood Security in a TMW in Pamana*

Indicators of livelihood security at farm household- level				
Farmers' satisfaction		**Resource conservation**	**Watershed development process**	
Farm household	Index[1]	Index[2]	Index[3]	Composite Index
1	2	3	4	5
1	0.5	0.4	0.5	0.5
2	0.1	0.3	0.9	0.4
3	0.8	0.5	0.3	0.5
4	1.1	0.4	0.6	0.7
5	0.4	0.4	0.3	0.4
6	0.0	0.4	0.2	0.2
7	0.6	0.5	0.6	0.6
8	0.7	0.5	0.4	0.5
9	0.6	0.5	0.7	0.6
10	0.0	0.4	0.6	0.3

Col.2 - Average of Col.2, 3 & 4 from Table 4; Col.3 - Average of Col.5, 6, 7& 8 from Table 4; Col. 4 - Average of Col. 9, 10, 11, 12, 13 & 14 from Table 4; Col. 5 - Average of Col. 2, 3, & 4 from Table 5

Index indicated in Col. 5, shows the average score gained by each of the ten households under the three issues mentioned earlier. The table suggests that *livelihood security* in TMW is better in case of household no. 4, 7 and 9 when compared to household no. 6 and 10 who have scored a lower Composite Index. In Table 6 agricultural situation in an untreated micro-watershed (UTMW) in the same village is indicated. The table indicates that of the five households evaluated, household no. 2 has achieved a better *livelihood security* when compared to household no.1. In the final analysis, the situation is marginally better in case of TMW when compared to that of UTMW in Pamana, although, sustainability of *livelihood security* had not been achieved as the Composite Index value was < 1.0 i.e., the threshold between sustainability and unsustainability, as mentioned in the algorithm earlier.

Fig. 1 illustrates how each of the twelve indicators had faired in the TMW and had contributed to *livelihood security* among the ten farmers selected for this analysis. It is indicated that while several farmers have been able to achieve higher yield gain, fewer had made gains with regard to *developing irrigation water resource, higher soil OC* and *fertility levels, slope management* and *consolidating land holdings to increase the size of holding* for undertaking agricultural operations in the TMW. Impact of *membership of Watershed Association (WA)* and *undertaking S&WC measures* as a result of WDP is evident but *accessibility to credit facility*

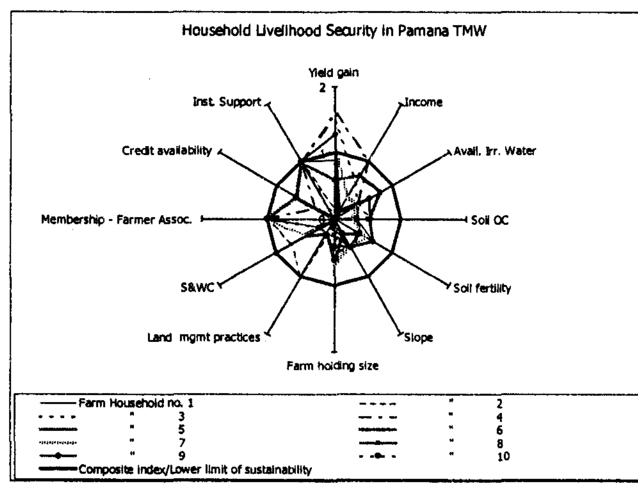

Fig. 1. *Livlihood security in Pamana TMW*

Table 6. *Contribution of WDP for achieving livelihood security in UTMW in Pamana*

Indicators of livelihood security of farm household																
	Farmers' satisfaction				Resource conservation					Watershed development process						
Farm House-hold no.	Yield gain from potential yield	Income	Irri. Water avail.	Index[1]	Soil OC content	Soil fertility status	Slope of land	Farm size	Index[2]	Land Mgmt prac.	S&WC meas	Member-ship farmer assoc.	Credit avail-ability	Inst. Support	Index[3]	Comp-osite Index
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	0.41	0.14	0.00	0.2	0.39	0.56	0.50	0.15	0.4	0.00	0.25	0.00	0.33	0.00	0.1	0.2
2	1.17	0.04	0.60	0.6	0.37	0.44	0.50	0.75	0.5	0.00	0.25	1.00	1.00	1.00	0.7	0.6
3	1.26	0.09	0.40	0.6	0.37	0.67	0.25	1.00	0.6	0.25	0.00	0.00	0.67	0.00	0.2	0.4
4	1.22	0.11	0.00	0.4	0.39	0.56	1.00	0.80	0.7	0.75	0.50	0.00	0.33	0.00	0.3	0.5
5	0.33	0.00	0.00	0.1	0.37	0.56	0.50	0.18	0.4	0.25	0.50	1.00	0.67	1.00	0.7	0.4

Col.5 - Average of Col.2, 3, 4; Col.10 - Average of Col.6, 7, 8, 9; Col.16 - Average of Col.11, 12, 13, 14, 15; Col.17 - Average of Col.5, 10, 16.

was still not easy. Hence, all households in the two micro-watersheds in Pamana had failed to achieve *livelihood security* in 2006-07. In case of UTMW as indicated in Figure 2, yield accrued to farmers was lower than that achieved in TMW. Due to non-implementation of WDP, soil fertility level, OC content, irrigation water sources and income level were lower when compared to TMW. It is thus, clear from the two figures that WDP has had a positive impact on *livelihood security* among a few households as shown by performance of the indicators. The aspects that needed to be improved further for achieving *livelihood security* were: *improvement in availability of irrigation water* for critical crop phenophases, *soil OC and fertility level, slope management*, and *higher level of adoption of S&WC measures and improved land management practices*, etc., which could ensure higher income.

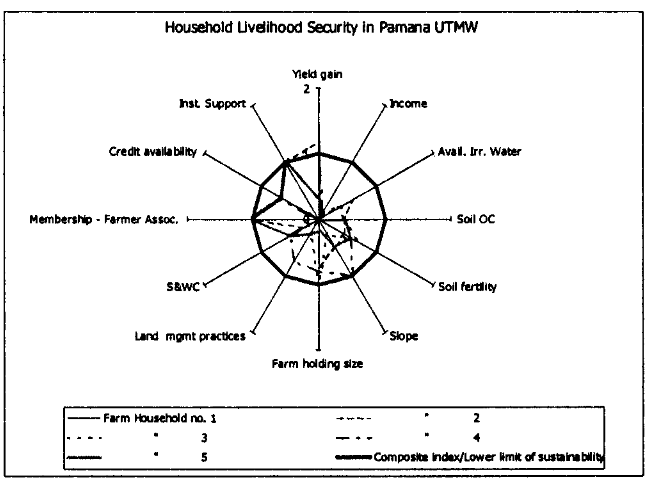

Fig. 2. *Household livelihood Security in Pamana UTMW*

Socio-economic survey undertaken during 2006 and 2007 indicated a marginal fall in crop yield by 4% which may be attributed to the poor performance of indicators depicted in Fig. 1 that could easily undermine the sustainability of *livelihood security* in TMW. The *farm size* indicator also denoted that small holdings of <1.0 to < 4.0 ha owned by 69% of farmers in the TMW and 66% in UTMW, did not ensure sustainable economic growth in the village.

With respect to WDP activities, the S&WC structures built during the project implementation phase were not maintained properly; neither were any additional structures built for conserving soil and water by stakeholders under their own initiative and the *Village Watershed Committee* (WC) and *Water Users Association* (WUA) had ceased to function by 2005 when the evaluation study was initiated. Credit availability from public-sector banks remained a problem as most farmers reported taking loan from local moneylenders and shopkeepers who sold seeds, pesticides and fertilizers on credit to the farmers resulting in unnecessary application of some of these inputs and increasing debt. Such lack of institutional support had triggered the incidence of farmer suicides in the southern states that forced Govt. of India to implement loan waiver package of Rs. 716.8 billion in 2008. The situation in UTMW was bad as farmers' practiced traditional methods of agriculture and failed to take advantage of modern techniques and methods (Table 5 and Fig.2). In order to analyse the impact of WDP on *livelihood security* various aspects related to economic returns from agriculture, were analyzed namely, income from agriculture, livestock and wages, input costs, net returns from farming and *Gini - coefficient* to understand equity distribution among stakeholders in the watersheds. During 2006 - 2007 net returns from the two micro-watersheds undertaken for study were analyzed and results have been presented here.

Net income

Analysis of household income (Table 3a) indicated a large variation in income from farming activity among farmers in both types of watersheds. For assessing change in net income, a sample of 39 farmers from TMW and 15 from UTMW was taken. Income was analyzed for each farmer category namely, marginal (with <1 ha of land holding), small (1-2 ha), semi-medium (2-4 ha) and medium (4-10 ha), in both watersheds, in order to compare and assess the impact of WDP. Components of household income like agriculture, livestock and wages were segregated for each category to understand which aspect of farming system, was important for a given category of farmer. Input costs were also analysed for each category. Change in income level was calculated for 2006 and 2007.

In case of Pamana TMW, income of 39 farmers at current price in 2006 ranged from Rs. 5241/- among marginal farmers to Rs. 10395/- among small farmers, Rs.18310/- among semi-medium and Rs. 74915/- among medium farmers. Income at constant price in 2006 was Rs. 2604.87 among marginal farmers and Rs. 37234/- among medium farmers (WPI with Base Year as 1993-94 =100). In 2007, income amongst the two categories of farmers at constant price, increased to Rs. 10,780.63 and 48,708.60, respectively. Increase in income was not necessarily due to agriculture under WDP, as NREGA scheme had been implemented in the village in 2007 that provided 35 % of income to marginal farmers while agriculture contributed 25.7% and livestock rearing provided 38.8% of income. Among small farmers, 54.5% income came from agriculture while 5.2% was provided by livestock husbandry. Importance of agriculture as a source of income increased with increase in size of landholding; semi-medium farmers with 2- 4 ha land earned 53.9% from agriculture while medium farmers with 4-10 ha earned 92.4% of income from agriculture.

In comparison, marginal farmers in Pamana UTMW earned 92% of income from wage, which accounted for 87.5 % among small farmers. Between 2006 and 2007 income from agriculture among semi-medium and medium farmers in UTMW fell from 86.1% to 45.7 among the first category and 85.7% to 22.2% among the later. However, contribution from wages increased to 53 and 75 % respectively, indicating the crucial contribution of Govt. aided development program like NREGA in providing *livelihood security* in untreated watersheds in rainfed regions. In fact, study indicated that WDP would benefit from dovetailing of other developmental projects like NREGA, *Swarnajayanti Gram Swarozgar Yojana* (SGSY - Golden Jubilee village self employment scheme) and other similar Govt. funded schemes.

Input costs

Input cost calculated according to *Cost A* definition for this study as mentioned earlier, included cost of equipments, seed, fertilizer, labour charge, land tax, depreciation of farm implements and interest on working capital. Cost of cultivation per unit area at current price among marginal farmers in TMW in 2006 was Rs. 9393.95 / ha, Rs.6512.75/ ha among small farmers, Rs. 7807.06 / ha amongst semi-medium and Rs. 4525.16 / ha among medium farmers while at constant price this cost was Rs. 4668.96/ha among marginal farmers and Rs. 3236.95/ha among small farmers. By 2007 input cost increased by 7.17% to Rs. 10753.38/ha at current price in case of marginal farmers (Rs. 5029.64/ha at constant price) and by 30% at Rs. 9971.52 / ha (Rs. 4663.95 / ha at constant price) among small farmers.

In UTMW, cost of cultivation in a hectare plot at current price in 2006 was Rs.5159.53 among marginal farmers (Rs. 2564.38/ha at constant price) and Rs.7634.71 (Rs. 3794.59/ ha at constant price) among small farmers. In 2007, input cost rose by 20.9% among marginal farmers i.e., Rs. 6933.09 /ha at current price (Rs. 3242.79/ha at constant price) but fell by 21% to Rs. 6704.95/ha at current price (Rs. 3136.09/ha at constant price) among small farmers.

Net returns from farming

Comparison of net income data between 2006 and 2007 in TMW across the villages indicated a net gain of 75.81 % among marginal farmers and 23.55% among medium farmers. These gains were seen to accrue through increase in wage income among marginal farmers and from agricultural income among medium farmers. In case of UTMW, increase in wage income was due to implementation of NREGA program, which is a relatively recent development and not a part of WDP in the village.

Gini - Coefficient

To understand equity or wealth distribution among farmers in Pamana village, the gross and net income accrued to farmers in both micro-watersheds were analyzed. In 2006, equity was poor among marginal farmers as Gini-coefficient was found to be 0.83 that improved slightly to 0.56 by 2007. *Gini-coefficient* among various categories of farmers in Pamana TMW in 2007 was measured at 0.56 in case of marginal farmers, 0.31 among small farmers and 0.30 in case of both semi-medium and medium farmers. In the UTMW in 2007, *Gini-coefficient* was found to be 0.40 among marginal farmers, 0.30 among small and semi-medium farmers and 0.26 among medium farmers. If WDP has to become sustainable, the program must be developed and implemented in such a manner that equity among farmers of all categories improve.

CONCLUSION

While households from both types of micro-watersheds in Pamana village were evaluated and found to have unsustainable livelihood with varying degrees of security, significantly three households in TMW secured scores ranging between 0.6 - 0.7 out of a threshold score of 1.0 which is considered the limit that differentiates sustainable from unsustainable *livelihood security* as illustrated in Figure 1. Except for yield levels in TMW which was higher than the threshold limit, all other indicators pertaining to *resource conservation* and *watershed development programs* used for this study, failed the test of sustainability. In case of UTMW (Fig.2) all indicators including *crop yield* were found to be unsustainable. Hence, it may be concluded that *livelihood security* was not adequately ensured by WDP implemented under DPAP in Pamana village.

As illustrated in this paper, the methodology developed facilitates a quantitative evaluation of impact of watershed projects in a study area. The study indicates that to achieve *livelihood security*, WDP must emphasis on two issues - *increasing crop yield* and *income*. Indicators useful for evaluating these two issues were identified as *development of sources of irrigation, soil OC content* and *fertility status, adoption of improved land management practices, slope management, S&WC measures*, etc. In order to convert the intangible aspects of agricultural management into tangible results, *institutional support* by way of increasing access to *institutional credit* and *creation of farmer associations* to protect their interests, were found to be vital for achieving *livelihood security*.

The methodology developed and presented in this paper could be useful for agencies involved in implementation of WDP as it can help in identifying aspects that need to be emphasized for success of the project on one hand, while helping to rectify the weak-links in the program, on the other. For WDP to be successful, it is critical that *livelihood security* becomes sustainable as indicated in this study. Role of WDP is undoubtedly pivotal to development of rainfed agriculture; however, there is a strong case for enlarging the scope of WDP for including other sources of income options for ensuring *livelihood security* through major modifications in the implementation of watershed projects.

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