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Sustainable agriculture production under diversification of farming systems for marginal household farmers

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Abstract
An experiment entitled "Sustainable agriculture production under diversification of farming systems for marginal household farmers" was carried out during 2022-23 on farmer's field in Karanja (Ghadge) & Ashti tehsils of Wardha district in Maharashtra for enhancing productivity, profitability, improve the livelihood, nutritional security and employment. Rs. 2,96,111 per annum per house hold was the highest net return recorded by Field crop + Horticulture + Dairy farming system which was Rs 1,19,561 more over the intervention in diversification and existing different components of farming system. Whereas net return recorded by Field crop + Dairy farming system i.e. Rs 2,22,095 per annum per house hold which was Rs 75,403 more over the benchmark.

Keywords: Diversification, intervention, marginal farmers, household

Introduction
Agriculture as a backbone of the Indian economy contributed in GDP which is gradually decline up to 14% because of land holding per farmer is less than 0.5 hectare with increasing Indian population with the expansion of urbanization and industrialization. This situation has created a serious problem of sustainability and food security in agriculture. Now it is essential to develop 85% of the farming community i.e. small and marginal farmers to enhance their productivity, profitability, improve the livelihood, nutritional security and employment generation. For calculating the profitability and sustainability small land holding pattern was major concern as rural agriculture is the base for Indian economy Meena *et al* (2018) [3]. new technology even though with potential fails to get desired impact because of complexity of small and marginal farmers which results with lower productivity, profitability, sustainability and flexible food system. In order to overcome poverty reduction, food security, sustainability and competitiveness such multiple objectives, several scientists have recommended the farming system approach. Farming with one enterprise is not viable and makes uncertainty in the livelihood of farmers in addition the climate change plays a major role in erratic and ill distribution of rainfall (Balumahendiran *et al* 2020) [1].

Fluctuating prices of commodity, labour shortage during peak agriculture season this factors have imposed a severe impact on resource deprived farm house holds income enhancement, now the focus of farmers started shifting to few enterprises in such cases it needs careful approach while transferring the appropriate technology as agro-ecology and resource management varies from one place to another. (Jashanjot Kaur *et al*. 2021) [2]. Lack of diversity as has cropped up ultimately threatening the sustainability of the system and economic stability of the farmer. Small and marginal farmers need to have multiple sources of income to ensure livelihood security, economic stability and risk coverage irrespective the percent contribution to total income, integrated farming system (IFS) seem to be promising solution.

Farming system reduces the risk due to abiotic and biotic factors, high cost of inputs, increase resource use efficiency, fulfills the nutritional requirement of farmer's family, meets the rising need of food, feed, fuel and increasing demand of soil nutrients. Besides improving the annual income it generate employment year round, improve standard of living and improve soil quality for sustainable agriculture, conserve the natural resources and minimize pollution hazards.

Keeping this need in view trials was conducted at farmer's field to study "Sustainable agriculture production under diversification of farming systems for marginal household

farmers" to enhance the productivity and profitability of marginal farmers households through IFS approach and to improve the livelihood and nutritional security through diversification approach.

Materials and Methods

A field experiment on "Sustainable agriculture production under diversification of farming systems for marginal household farmers" was carried out during 2022-23 on farmer's field in Karanja (Ghadge) & Ashti tehsils in Wardha district of Maharashtra. The intervention planning based on identified constraints for different components of farming systems including field crops along with allied enterprises (horticulture crops, livestock etc.) in a systems perspective with multilevel interventions on the farmers' fields to get multifold increase in net income.

Treatments (Modules)

M M_0	Bench Marks: Recording bench mark through comprehensive survey, videography along with GPS location.
M_1	Cropping system diversification: The most efficient cropping system to be introduced keeping in view the farmers resources /perception /willingness /market / household requirements and other components of the system.
M_2	Livestock diversification: Introduction of region specific low cost livestock components *viz*. backyard poultry and goat etc. + improvement of livestock health and productivity through improved nutrition (mineral mixture) + de-worming + round the year recommended fodder supply.
M_3	Product diversification: On-farm preparation of mineral mixture/ value addition in marketable surplus product/ kitchen gardening / roof gardening etc.
M_4	Capacity building: Training of farm households on farming systems including post-harvest and value addition (support with critical inputs and assessing its impact.)

Results and Discussion

Prototype farming systems developed based on characterization of the region including the different components like crop, horticulture and dairy was found to be sustainable and eco-friendly.

As per analysis of the house hold survey data of farmers, results stated that, farmers had an average 0.97 to 1.07 hectare land holding, higher number of local cattle (1.0 number) in comparison to improved cattle breeds (0–1 number).

Table 1: Types of Farming Systems and components

Farming System (s)	No. of households	Mean holding size (ha)	Mean family size (no's)	Cropping systems	Livestock	Mean benchmark off farm income (Rs/hh)	Mean benchmark net income from farming (Rs/hh)
Crop + Horticulture + Dairy	15	1.07	3.80	Kharif Bt cotton+ Pigeon pea (6) Sole Soybean (9) Rabi Sole Chickpea (9) Sole Wheat (6)	Cow Av. No (1.0)	Nil	176550
Crop + Dairy	9	0.97	3.88	Kharif Bt cotton+ Pigeon pea (2) Sole Soybean (7) Rabi Sole Chickpea (7) Sole Wheat (2)	Cow Av. No (1.0)	Nil	146692

24 farmers were studied, on the basis of bench mark survey of targeted group information was analyzed, and on the basis of various components the farming system was classified in two group of farming system Crop + Horticulture + Dairy and Field crop +Dairy.

Table 1 and 2 showed that the total net income from Crop + Horticulture + Dairy was recorded Rs. 1,76,550 per year per household from total holding size in bench mark, followed by Field crop +Dairy i.e. Rs1,46,692 per year per household. Overall 69% income generated by crop component of farming system, 26% income generated by horticulture component of farming system and only 5% income produced from dairy component.

Table 2: Benchmark status of area and net income from various modules

Farming System (s)	Benchmark net income (Rs/hh)					
	Cropping systems	Horticulture crops	Livestock diversification	Other components if any	Product diversification	Total
Crop + Horticulture + Dairy	121187	46722	8641	0	0	176550
Crop + Dairy	136405	--	10287	0	0	146692

Identifying constraints and possible interventions

Across the chosen village locations major constraints in farming system based on the household survey data were identified. After that, consultation with concerned local expert, survey and non- survey participants the potential interventions were identified to address in existing and diversification mode, constraints were identified and interventions are planned and executed accordingly to record the change in net returns obtained by each farm house holds per annum.

Possible low-cost interventions for farmers was implemented after identification of the problems and also evaluated based

on identified constraints for farm types as well as availability of resources at farm. Refinement of existing system was carried out no intervention involving drastic change was considered after evaluating the choice of the farmers, his knowledge about the selected enterprise, risk bearing capacity and available resource. The income obtained after technological intervention was compared with benchmark income and results obtained in terms of net returns per annum per household.

As per farmers in the crop component, the non-availability of high yielding variety quality/improved seeds was a very serious constraint. Also, the yield has been stagnated, after a certain peak that may be due to imbalanced nutrient application, etc. For addressing low yield, seed of improved varieties, bio fertilizer and bio fungicides for seed treatment, proper integrated weed management practices, irrigation at crops critical growth stages, pest and disease management practices along with inputs and technical know-how were introduced, for balanced nutrition in crops recommended fertilizer dose of NPK along with micro nutrients were also included for higher yield. Further, intercropping and diversification with new crops (pulses, oilseed) fetching promising prices in market to enhance the income from crop component were introduced.

In animal component due to low milk production per lactation period less income was recorded as a result of non-availability of good quality green and dry fodder during lean period, mineral and vitamin deficiency, due to poor health and lacks of technical know how about proper rearing of livestock, the farmers weren't aware of the scientific approach. Interventions like inclusion of perennial and seasonal green fodder crop for year-round fodder availability, hay making, mineral mixture supplementation, deworming of animals were done to address the constraints related to low milk production and animal health.

On horticulture aspect fruit and vegetable cultivation in orchard was incorporated, inputs for balanced nutrition, bio fungicides for citrus orchards were provided along with seed and seedling of vegetable crops. It helps towards balanced and rich nutrition, food self-sufficiency to the farm family and increase profit margin from the same piece of land.

Compost making was also included for proper recycling of resources and utilization of waste of one enterprise as input for the other enterprise, bio decomposers and technical knowledge of proper composting methods was provided. Nutrient recycling reduces dependency on the external input and enables self-sustainability of the system reducing the cost of production which leads to enhanced profit.

The targeted intervention will provides risk coverage against fluctuations in market prices and climatic change conditions to farm house hold. Farmer can tactically adjust the allocation of input between and across enterprises accordingly as targeted intervention is done in integrated manner which will help him to choose proper cropping system and enterprise based on objectives like productivity, profitability, nutritional security and meeting household requirement etc.

Table 3: Salient features of interventions for diversification in each module

M_1	Cropping system diversification	Intervention in existing	Intervention in diversification
	Crop		
1		Balancing of major plant nutrients along with micronutrients.	Use of nano fertilizers + Foliar application of micro nutrients at critical growth stage.
2		Seed treatment with bio agents, pest and weed control.	Providing bio-fertilizers, bio- fungicide, pesticides and weedicides.
3		Intercropping (Pulse & Oilseed crops).	Introduction of linseed & mustard crop.
4		Protective irrigation at critical growth stage.	In situ moisture conservation, BBF cultivation.
5		Imparting knowledge on package of practices.	Truthful seed production.
6		Seed priming/ seed soaking.	Crop intensification.
	Horticulture		
1		Nutrient management.	Supply of disease free (phytophthora) planting material.
2		Disease free nursery management.	Providing phytophthora management kit (Fungicide, Insecticide, Nutrition etc.).
3		Intercropping with vegetable and floriculture crops in orchards.	Providing seed of vegetable and floriculture crops.
4		Fruit drop management.	Providing potassium nitrate/calcium nitrate and PGR GA/NAA for proper fruit retention.
M_2	**Livestock**		
1		Imparting knowledge on preparation of home-made concentrate mixture.	Supply of mineral mixture or mineral bricks and vitamins.
2		Demonstration on (Ammonification) treating low quality straw with salt, urea & jagerry.	Supply of forage crop seed/saplings.
3		Imparting knowledge on animal vaccination, insurance, cleaning, grooming and artificial insemination.	Providing poultry birds or goats.
4		Imparting knowledge on importance of minerals and vitamins for animals.	-
M_3	**Product diversification**		
1		Proper compost making method.	Providing bio decomposer /urea, SSP for fast and proper decomposition/enriched compost.
2		Technical knowledge on cultivation of vegetable crop round the year.	Boundary plantation of dry land horticulture or forestry crops.
3		Value addition of surplus produce.	Preparation of concentrate mixture from low grade grains.
4			Providing Kitchen gardening kit.

M_4	Capacity building	
1		Trainings on package of practices of crop production (nutrient, weed, irrigation, pest & disease management
2		Training on disease free nursery raising, phytophthora, fruit drop and greening management
3		Training on vegetable /floriculture crop production
4		Training on goat/poultry raising/rearing
5		Training on concentrate mineral mixture preparation and ammonification (treated straw)

Table 4: Cropping system-Crop +Horticulture + Dairy (No. of farmers-15) Crop

Sr. No	No. of farmers	Crop	Yield (kg/ ha)	Rate /kg(Rs)	Gross return (Rs/ha)	COC (Rs/ha)	Net return (Rs/ha)	Benchmark (Rs)
1	9	Soybean	1275	45	57375	25979	31396	
2	6	Cotton + Tur	1400+190	68+70	95200 + 13300 = 108500	33960	74540	
3	14	Chickpea + Linseed	1425+90	54+50	76950 + 4500 = 81450	15830	65620	
4	1	Wheat + Mustard	2100+100	18+54	37800 + 5400 = 43200	18854	24346	
				Total	290525	94623	195902	121187
					Increase over benchmark (Rs)			74715
					Increase over benchmark (%)			38.14

Horticulture

Sr. No	No. of farmers	Crop	Yield (ton/kg/0.40ha)	Rate/ton/kg (Rs)	Gross return (Rs/0.4ha)	COC (Rs/0.4ha)	Net return (Rs/0.4ha)	Benchmark (Rs)
1	15	Orange	3.5 ton	20000/ton	70000	15400	54600	
2	15	Brinjal	1250 kg	10/kg	12500		orange	
3	15	Chilly	750 kg	20/kg	15000			
4	15	Coriander	400 kg	10/kg	4000	9261		
5	15	Spinach	400 kg	7/kg	2800		25039	
				Orange (a)	70000		Vegetable	
				Vegetable (b)	34300			
				Total(a+b)	104300	24661	79639	46722
				Increase over benchmark (Rs)				32917
				Increase over benchmark (%)				41.33

Dairy

Sr. No	No. of farmers	Lactation period (Days)	Milk yield (lit/ day)	Total milk yield (lit)	Rate (Rs/lit)	Gross return (Rs)	Cost of rearing (Rs)	Net return (Rs)	Benchmark (Rs)
1	15	130	3.4	442	50	22100	4420	17680	
							Total	17680	8641
					Increase over benchmark (Rs)				9039
					Increase over benchmark (%)				51.12

Product Diversification

Sr. No	No. of farmers	Nutritional Garden kit	Weight	Yield (kg)/ farmer	Rate (Rs/kg)	Net return (Rs)
1	15	1 kit/farmer	50g	70 kg	7.0	490
Sr. No	**No. of farmers**	**Bio Decomposer**	**Weight**	**Compost (q)**	**Rate (Rs/ q)**	**Net return (Rs)**
2	15	1 packet/ farmer	1.0 kg	6.0 q	400	2400
					Total	2890

The total net income increase over benchmark per annum per household in crop, horticulture and dairy component was Rs 74,715/-, 32,917/- and 9,039/-, respectively and increase over benchmark in percentage was 38.14, 41.33 and 51.12%, respectively. The additional net income gain through product diversification is Rs 2,890 per annum per household in Crop + Horticulture + Dairy farming system.

Table 5: Cropping system-Crop + Dairy (No. of farmers-09) Crop

Sr. No	No. of farmers	Crop	Yield (kg/ ha)	Rate /kg(Rs)	Gross return (Rs/ha)	COC (Rs/ha)	Net return (Rs/ha)	Benchmark (Rs)
1	7	Soybean	1320	45	59400	25980	33420	
2	2	Cotton + Tur	1425 + 190	68 + 70	96900 + 13300 = 110200	33530	76670	
3	7	Chickpea + Linseed	1425 + 80	54 + 50	76950 + 4000 =80950	15274	65676	
4	2	Wheat + Mustard	2250 + 125	18 + 54	40500 + 6750 =47250	19920	27330	
				Total	297800	94704	203096	136405
					Increase over benchmark (Rs)			66691
					Increase over benchmark (%)			32.84

Dairy

Sr. No	No. of farmers	Lactation period (Days)	Milk yield (lit/ day)	Total milk yield (lit)	Rate (Rs/ lit)	Gross return (Rs)	Cost of rearing (Rs)	Net return (Rs)	Benchmark (Rs)
1	9	120	3.5	420	50	21000	4933	16067	
					Total			16067	10287
					Increase over benchmark (Rs)				5780
					Increase over benchmark (%)				35.97

Product Diversification

Sr. No	No. of farmers	Nutritional Garden kit	Weight	Yield (kg)/ farmer	Rate Rs/kg	Net return (Rs)
1	09	1 kit/farmer	50g	76 kg	7.0	532
Sr. No	**No. of farmers**	**Bio Decomposer**	**Weight**	**Compost (q)**	**Rate (Rs/q)**	**Net return (Rs)**
2	09	1 packet/ farmer	1.0 kg	6.0 q	400	2400
					Total	2932

The total net income increase over benchmark per annum per household in crop and dairy component was Rs 66,691 and 5,780 and increase over benchmark in percentage was 32.84 and 35.97% respectively. The additional net income gain through product diversification is Rs 2,932 per annum per household in Crop+ Dairy farming system.

Table 6: Net benefit due to interventions

Farming Systems	Holding size (ha)	Interventional cost (Rs/hh)					Net income due to interventions (Rs/hh)				
		Cropping System.	Horticulture	Dairy	Product diversification	Total	Cropping System	Horticulture	Dairy	Product diversification	Total (Rs)
Crop + + Horticulture + Dairy	1.07	10865	2437.5	713	200	13502.5	195902	79639	17680	2890	296111
Crop + Dairy	0.97	10865	--	713	200	11065	203096	--	16067	2932	222095

Table 7: Improvement of total net income (Rs) and natural resources

Farming Systems	Holding size (ha)	Net income (Rs/hh)			
		Benchmark* (Rs)	After diversification in Rs (First year)	Income over Benchmark (Rs/hh)	Increase over Benchmark (%)
Crop + Horticulture + Dairy	1.07	176550	296111	119561	40
Crop + Dairy	0.97	146692	222095	75403	34

In present study interventions consisting of improved crop varieties, seed treatment, balanced nutrition, improved cultivation practices, crop diversification, introduction of vegetable crops, improved management of citrus orchard, proper livestock feeding, rearing practices, farm waste recycling, kitchen gardening and training programme for capacity building. Due to interventions in existing and diversification of farming system net benefit due to interventions was increased on 0.20 ha area. The highest net return of Rs. 2,96,111 per annum per house hold was recorded by Field crop +Horticulture+ Dairy farming system after intervention in existing and diversification of farming system i.e. Rs 1,19,561 more over the benchmark, Hence, after intervention of farming system 40% increase in net income was recorded. Whereas net return recorded by Field crop+ Dairy farming system i.e. Rs 2,22,095 per annum per house hold which was Rs 75,403 more over the benchmark i.e. 34% more net income over the benchmark. The results are in line with Shweta *et al*. (2020) [4].

Small and marginal farmers can proceed towards sustainability and economic viability by adopting these interventions of the agricultural production system. It is difficult for farm family, to sustain from crops income throughout the year, so regular cash flow is required which is only possible when the crop is combined with judicious combination of enterprises feasible in the environmental conditions of the area. Singh *et al*. (2012) [5], Singh and Ravisankar (2015) [6].

The results suggest that recommendations to enhance farmer's income should be case specific instead of the blanket application for whole area. Ray of hope to enhance the net return especially of resource constraint farmers provided if interventions are planned through identification of farm types approach, reduce cost of production, risk and increase farm income in a holistic manner for reaping the benefits.

Thus from the experiment for enhancing the productivity and profitability of marginal farmer's households through IFS approach by interventions and improvement in the livelihood and nutritional security through diversification approach. The best farming system with highest net return of Rs. 2,96,111 per annum per house hold and 40% increase over benchmark was recorded by Field crop + Horticulture+ Dairy farming system after intervention in existing and diversification in different component of farming system. Field Crop + +Dairy farming system recorded net return of Rs 2,22,095 per annum per house hold and 34% increase over benchmark.

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