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MANAGEMENT OF RESOURCES FOR SUSTAINABLE AGRICULTURE

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Abstract

Green Revolution triggered in India with the introduction of high yielding varieties of crops particularly wheat and rice in seventies. The cultivators rapidly adopted these varieties in North India, which produced high yields by greatly responding to modern inputs, generation of suitable crop production and protection technologies and favourable public policies. But continuation of same cropping patterns over the last three decades with inefficient and indiscriminate use of agro-chemicals inputs as well as natural resources have resulted into mounting environmental problems. The shrinking of natural resources coupled with technology and public policy related problems have caused increase in cost of production over the years. Considering various factors like optimization of agricultural productivity and profitability, employment generation, natural resource conservation and reduction in agro- chemical use, the objectives framed were i) to study utilization pattern of land, water and agro-chemicals in perspective ii) to formulate suitable farm plans for sustainable production.

The investigation was carried out in Haryana being one of the states of Indian Union which experienced green revolution in the first instance of its introduction has witnessed impressive increase in food grains production from 25.92 to130.65 lakh tones during the period 1966-2000. Moreover, it improves its relative position in terms of per capita income and second in position for contributing to national food grain pool. The data with regards to land use pattern, irrigation water, cropping pattern etc. were scanned from various published sources. The gross returns for different crop enterprises were calculated by taking average productivity of a particular crop for triennium ending 2001 and post harvest prices of current year. Linear Programming Technique (LPT) was employed to make rescheduling of resources on sustainable lines.

The results of the study reveal that area under forests does not indicate any appreciable increase over the years. The cropping pattern exhibited the acreage concentration of resource exhaustive and less risky crops like cotton, wheat, sugarcane and paddy and most of irrigation water were used amongst these crops. Increased consumption of nitrogenous fertilizers and pesticides, continuation of same cropping pattern over the time period resulted into accentuating the area under problematic soils, depletion of underground water, infestation of weeds, insect-pests and diseases. The optimal sustainable production plans showed increase in gross returns as well as accrued benefits through saving the water and agro-chemicals. The optimal plans in corporation the crop enterprises like green gram, black gram, soyabean, groundnut etc not only improved the soil health but also reduction in use of natural resources and agro-chemicals. The optimal plans further make sure to accommodate the economic, ecological and social aspects paving the path for sustainable development in agriculture.

Introduction

Sustainable agriculture is that form of farming which produces sufficient food to meet the needs of the present generation without eroding the ecological assets and the productivity of the life supporting system of the future generations (FAO,1989). Green Revolution triggered in India with the introduction of high yielding varieties of crops particularly wheat and rice in seventies. The cultivators rapidly adopted these varieties in North India, which produced high yields by greatly responding to modern inputs, generation of suitable crop production and protection technologies and favourable public policies. With the increase in crop yields from modern farming techniques, reaching plateau and the mounting environmental problems, the need for sustainable and ecological agriculture is increasing being felt in the country. The bio-chemical technology introduced in the mid-sixties has been the major exogenous technological change witnessed by Indian agriculture. No doubt, India has emerged from a food deficit to self But continuation of same cropping patterns over the last three decades with inefficient and indiscriminate use of agro-chemicals inputs as well as natural resources have resulted into mounting environmental problems. The shrinking of natural resources coupled with technology and public policy related problems have caused increase in cost of production over the years .Therefore, the option opens is to iterate in between the losses and gains of the present technology and the input use in vogue and make gradual shift towards the sustainable pattern keeping in view the present and future needs.

Haryana being one of the states of Indian Union experienced Green Revolution in the first instance of its introduction has exhibited impressive manifold increase in food grain production from about 25.92 lakh tonnes in 1966-67 to 130.65 lakh tonnes in 2000-01.More ,it ranks second next to Punjab state in productivity of all most crops and second largest contributor to national food grain pool. In addition, it also produces a large quantity of cotton, oilseeds, sugar, vegetables, flowers and animals products such as milk, eggs and broilers. About 77 percent of net sown area is irrigated using various irrigation sources like canal water, tubewell, sprinkler and drip irrigation water saving technologies.

The expansion of wheat and paddy area has nearly halted, growth in their productivity is observed from data recorded has been slowed and productivity growth appear to be achieved highest potential. Declining soil fertility, organic matter loss water induced land degradation,declining /raising water table, increasing nitrate content in ground water and soil, hazardous residual contents in food and fodder chain and threat to flora and fauna need attention. The main threat to agriculture is diminishing resource base in two ways, by depletion and contamination. Both problems have an impact far beyond agriculture, in that resulting loss of food production and environmental damage threaten and diminish quality of life. With these and associated considerations, all along with their repercussions in view, the following objectives were framed for the present study:

Objectives

i) to study utilization pattern of land, water and agro-chemicals in perspective
ii) to formulate suitable farm plans for sustainable production

Methodology

The paper is based primarily on secondary data scanned from various issues of Statistical Abstracts of Haryana for the period 1981-2001, publications of Departments of Agriculture and Irrigation, Government of Haryana, publications of CCS Haryana Agricultural University, Hisar and other published sources. The gross return from different crops were calculated by taking average productivity of a particular crop for the triennium ending 2000-01 and multiplying by the post- harvest price for the year 2000-01. The crop wise detailed information has been presented in table 1. The average input prices considered for the water (Rs./metre ha.) fertilizers(Nitrogen, Phosphorous and Potash in Rs./ kg in nutrient) and pesticides (Rs./ kg/ litre) were calculated wereRs,Rs1970,Rs.9.56,Rs.15.38,Rs.5.14 and Rs.218, respectively.

Linear programming technique(LPT) was employed to make the rescheduling of resources on sustain lines. The crops having more requirement of water and agro-chemicals were substituted with requiring less of it with 10,15 and 20 percent area reduction (Table 2). After long discussion with crop scientists, crops were substituted having importance in maintaining and improving soil health.

The existing area of a crop considered as an average area of the crop during the preceding three years. For the pesticides consumption, the average consumption of period 1998-01 were taken in account and then on the based on the opinion survey of entomologist, the crop –wise consumption (in percentage) was worked out.

Besides crop acreages, water and fertilizers availabilities were used as restrictions or constraints to formulate the possible alternative crop plans at various levels of area substitution .The input-output prices as well as productivity levels were remains constant in all the plans.

Results And Discussion

Land use pattern

It is evident from the table 3 that there has not been any substantial change in area under forest during the period 1980-2001. The forest area showed the sign of rising trend upto 1991-92 failed to maintain and declined to ever lowest figure of 115 thousand hectares in1996-97.On average, the forest area in the state accounted for less than 4 percent of total geographical area. Barring the years1987-88 and 1992-93 more than 80 percent of the area has been utilized for crops. More than half of the net sown area(except few years) has been double cropped. The cropping intensity was recorded as high as 173.42 percent.

Cropping pattern

The overall account of share of different crops in total cropped area for the state as whole is presented in table 4.The first four crops in percentage viz; wheat, pearl millet, chickpea and paddy accounted for the highest share of total cropped area during the year 1980-81. But the order changed to wheat, paddy, cotton, rapeseed and pearl millet in the year 2000-01.cereal based cropping pattern sharing more than 50 percent acreage indicate overall risk of crop concentration in the long run on a few crops instead of diversification, thus cultivators prone themselves to disaster and thereby set the stage for potential wide spread crop losses in future . Paddy, cotton and wheat being resource exhaustive crops put a severe drain on natural resources like water and soil micro-nutrients, thus posing threat on the long term sustainability of the existing scarce resource base.

Area irrigated of important crops

The assured supply of irrigation water in most of the area had the mainstay of agricultural development. The area under pearl millet indicated increasing trend. In case of gram also, area irrigated fluctuated over the years with a downward trend, it reached a high of 65.45 percent in 1987-88 (Table 5). This might be on account of shifting of pearl millet and chickpea acreage to the more assured and less risky crops of paddy and wheat with increased availability of irrigation water. This trend of percentage area under irrigation under paddy, wheat ,cotton and sugarcane follow the path of sustenance. This might be due to stability, responsiveness to modern technology/inputs and high returns from these crops. With increased irrigation coverage, most of irrigation water was shared amongst paddy, wheat, cotton, sugarcane and the like crops while pearl millet and chickpea got reduced area under irrigation. The area under irrigation got reduced in case of oilseeds, pulses and coarse cereals.

Use of agro chemicals

With the advent of the green revolution,the use of modern inputs, especially agro-chemicals, has increased manifold, owing to responsiveness of high yielding strains to irrigation, chemicals etc. The consumption pattern of major plant nutrients viz; nitrogen, phosphorous and potash as well as pesticides as portrayed in table 6.From total use of fertilizers i.e. 64.08 kg/ha .in 1980-81,the consumption pattern shows an increasing trend (barring potash) has reached a high of 261.90 kg/ha in 2000-01 with contribution of nitrogen, phosphorous and potash being 201.10,58.08 and 2.72kg/ha.,respectively. The overall emerging issue of the consumption pattern of nitrogen, phosphorous and potash indicates the increasing trend over the years in respect of nitrogen followed by phosphorous and potash. The consumption of pesticides has also increased over the years with upward inclination upto 1991-92.Thereafter,it exhibited declining trend. The ever increasing trend in pesticides consumption which has put a question mark on the sustainability of the present system has shown some sense of relief after the year1991-92 showing declining trend. Indiscriminate use of pesticides wipes out the natural enemies of pests, encourages the development of resistant strains of the pests. And hazardous effect on human life.

Ground water quality, change in water table and extent of problematic areas

The overall repercussion associated with farm activities have changed the scenario of ground water quality, water table and increase in problematic area. Nearly 55 percent water seems to be unfit for crop production and water table is declining by one feet each year. The foregoing discussion discerns the fact that the average acreage under plough has reached its peak and it is likely to decrease with increased urbanisation. Creation of intensive irrigation facilities, excessive use of canal water and the irrational use of crucial farm inputs have resulted in the problems of water logging, soil salinity, soil sodicity, etc.

Resource use pattern

At present, the cultivators considering a change in farming practices is the likely economic outcome. Wider adoption of sustainable farming methods requires that they should at least be as profitable as existing methods along with non-monetary advantages without rapidly deteriorating soil and water resources. The major stress is laid on crop component, its diversification, crop mix and their visual impact on land, water use and consumption of agro-chemicals. Based on these considerations and priority approaches , the linear programming Technique(LPT) was used to work out the alternate optimal crop plans.

In order of acreage, the major crops in the existing crop plan were wheat, paddy, pearl millet, rapeseed, chickpea, cotton and sugarcane (Table 7). In the existing optimal plan, there was no change in chickpea, cotton ,sugarcane and potato acreages. Barley disappeared from the plan where as area under paddy, maize and rapeseed increased. The changing crop acreages under different suggested optimal plans, give vivid picture of constant acreage under pearl millet, cotton and sugarcane. The acreage under chickpea, potato, red gram, green gram, soybean and lentil got substantially increase in the subsequent plans while there was up declining trend for rapeseed. Wheat and paddy witnessed declining trend in the optimal plan III. Barley escapes its inclusion in all optimal plans while maize excluded in optimal plan III.

The increasing acreage under pulses, oilseeds and other leguminous crops with decreased area under paddy, wheat and cotton in the optimal plans made a better change for crop rotation and the crop mix. Finally, it will help in attaining the ultimate objective of lessening the use of irrigation water and agro-chemicals, thereby paving the path for the sustainable agriculture.

Input use pattern

The basic aim is to reduce the use of crucial farm resources like water and agro-chemicals without causing any adverse impact on farm income. In all other plans, the water requirement indicated declining trend (Table 8). But it came down to 2612.71 thousand metre hectares in the optimal plan III. The gradual reduction in fertilizer requirement in the subsequent plans seems to be virtual possibly with maximum reduction of 9.87 percent in the optimal plan III.. Barring the potash consumption in the subsequent optimal plans, the nitrogen and phosphorous consumption got reduced upto 11.17 and 4.12 percent, respectively in the suggested optimal plan III. The pesticide consumption pattern exhibits down trend. From 3217.68 thousand kg in the existing plan, it reached to 3343.52 thousand kg in the optimal plan and from there to 3342.81 thousand kg in the suggested optimal plan III, indicating thereby an increase of 3.89 percent over the existing optimal plan. Although, there is not much increase on pesticides front, on account of increasing potato acreages. The reducing phenomenon consequent upon the changed crop acreages in the optimal crop plans, will improve soil fertility and productivity, enhance biotic activity and limit the adverse hydrological change.

Saving benefits accrued

The accrued saving benefits tread a varied path. All the optimal plans showed the saving in water requirement, The fertilizer saving got increased and reached to peak in optimal plan III. Similarly, the nitrogen and phosphorous savings exhibited the trend. The pesticides saving pattern exposed the negative trend in all the optimal plans with little bit difference. As result ,total saving benefits accrued in the existing optimal plan turned out to be a negative sum of Rs.68805.53 thousands(Table 9). Benefits in subsequent optimal plans show the increasing trend with highest in the suggested optimal plan III. The reduced use of critical farm inputs viz; water and agro–chemicals will open a new window for economic, social and ecological considerations. Thus, in this way, it will add to economic benefits with reduced use of purchased inputs, curtail the harmful and hazardous effects and build up soil structure and texture.

Pattern of returns

With changes in acreages under different optimal plans, the input use pattern as well as return sunder went a change. The emerged out pattern of return has been presented in table 10. it reveals that gross returns fro the crop production activity in the subsequent suggested optimal plans decreased marginally. The saving benefits accrued over the existing plan turned out to be a positive. There after, it showed an upward trend through successive optimal plans. The resulted positive changes in saving benefits in successive optimal plans. The least reduction of 0.16 percent was observed in the optimal plan II considering gross returns plus saving benefits.

The findings further reveal that with an initial minor set back ,it picked up in the successive optimal plans. Moreover, the changed pattern of returns will have to be viewed not only from economic consideration but also taken into consideration viz; said and unsaid quantification, qualitativeness on food front, ecological dimensions and sustainable growth parameters.

The results of the study reveal that area under forests does not indicate any appreciable increase over the years. The cropping pattern exhibited the acreage concentration of resource exhaustive and less risky crops like cotton, wheat, sugarcane and paddy and most of irrigation water were used amongst these crops. Increased consumption of nitrogenous fertilizers and pesticides, continuation of same cropping pattern over the time period resulted into accentuating the area under problematic soils, depletion of underground water, infestation of weeds, insect-pests and diseases. The optimal sustainable production plans showed increase in gross returns as well as accrued benefits through saving the water and agro-chemicals. The optimal plans in corporation the crop enterprises like green gram, black gram, soybean, groundnut etc not only improved the soil health but also reduction in use of natural resources and agro-chemicals. The optimal plans further make sure to accommodate the economic, ecological and social aspects paving the path for sustainable development in agriculture.

Conclusions

The analysis concludes that that area under forests does not show any appreciable increase over the years. However, intensity of cropping has increased. The cropping pattern vividly exhibits the acreage concentration of the resource exhaustive crops like paddy, wheat, cotton and sugarcane. Most of the irrigation water was shared amongst these crops. Fertilizer consumption pattern discerns the increasing trend at disproportionate rate over the years. Consumption of nitrogenous fertilizers increased at much faster rate than that of phosphatic and potashic fertilizers. Continuing adoption of the same cropping pattern have resulted into accentuating the are under problematic soils and distributing hydrological balance. How ever the input use pattern of water and agro- chemicals exhibits the reducing trend under successive optimal plans. The benefits brought about savings in water and agro–chemicals are likely to open new window for economic, social and ecological frontiers. In order to respond dynamically to current challenges, policies like water pricing, water shed management, diversification, change crop rotations and crop-mix to make progress towards profitable and environmentally sustainable production systems. Region-wise centres for sustainable agriculture should be established with multi disciplinary teams of physical, biological and social scientists for creation of data bank on sustainable parameters which will help make more informed choices.

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Table 1:Water. fertilizer requirements(recommended).pesticides consumption and gross returns.

Sr.No.	Crop	**Recommended water requirement** (metre ha.)	Recommended fertilizer requirement(kg/ha.)			Pesticides consumption (%)	Gross return (Rs./ha.)
			Nitrogen	Phosphorous	Potash		
1.	Paddy	1.300	150	75	60	11.00	18397
2.	Pearl millet	0.225	40	20	-	2.20	3986
3.	Maize	0.350	150	60	60	1.00	10431
4.	Wheat	0.325	150	60	60	5.50	24784
5.	Barley	0.225	112	60	30	1.00	10885
6.	Sunflower	0.450	80	60	-		13785
7.	Chickpea	0.115	15	40	-	1.50	12071
8.	Rapeseed	0.175	40	20	-	4.50	15771
9.	Cotton	0.450	150	60	60	22.50	14832
10.	Sugarcane	1.450	150	60	-	7.00	7980
11.	Potato	0.350	150	50	100	1.50	27510
12.	Red gram	0.200	15	40	-	1.00	8977
13.	Green gram	0.200	15	40	-	1.00	8029
14.	Soybean	0.200	25	80	-	-	9018
15.	Lentil	0.200	15	40	-	-	11545

Table 2: Area replacement and substitution of crops.

Sr.No.	Area reduction (10%.15 and 20%) crop	Area substitution crop
1.	Paddy	Soybean+ red gram + green gram
2.	Wheat	Sunflower+ chickpea+ rapeseed+ potato +lentil
3.	Cotton	maize+ red gram+ green gram

Table 3. land use pattern .

(000,ha.)

Year	Total area	Forest area	Land not available for cultivation	Permanent pastures and other grazing land	Culturable waste	Current fallow	Net sown area	Area sown more once	Total cropped area	Cropping intensity
1980-81	4405	132	434	30	30	177	3602(81.77)	1860	5462	151.64
1981-82	4405	134	425	25	41	120	3660(83.09)	2166	5826	159.18
1982-83	4405	136	417	27	48	170	3596(81.84)	1710	5306	147.55
1983-84	4394	130	405	27	47	185	3600(81.93)	2088	5688	158.00
1984-85	4391	132	402	27	46	168	3616(82.35)	1896	5512	152.43
1985-86	4391	166	392	28	23	168	3613(82.28)	1988	5601	155.02
1986-87	4391	169	390	28	23	158	3622(82.49)	2040	5662	156.32
1987-88	4391	166	405	30	23	528	3233(73.63))	1453	4686	144.94

1988-89	4391	166	398	26	25	209	3564(81.16)	2448	6012	168.69
1989-90	4380	168	391	21	29	175	3593(82.02)	2058	5651	157.28
1990-91	4378	169	417	23	21	169	3575(81.66)	2344	5919	165.57
1991-92	4385	170	379	25	43	256	3508(80.00)	2062	5570	158.78
1992-93	4376	171	405	31	33	240	3492(79.78)	2361	5883	167.61
1993-94	4374	167	413	29	38	209	3513(80.31)	2302	5815	165.53
1994-95	4369	110	498	27	14	156	3559(81.46)	2430	5989	168.28
1995-96	4398	110	494	24	23	156	3586(81.54)	2388	5974	166.59
1996-97	4399	115	480	24	23	137	3615(82.18)	2459	6074	168.02
1997-98	4402	115	441	25	37	149	3635(82.58)	2508	6143	168.99
1998-99	4394	115	440	24	37	144	3628(82.57)	2692	6320	174.20
1999-00	4400	115	464	22	23	219	3552(80.72)	2477	6029	169.73
2000-01	4402	115	470	34	18	232	3526(80.10)	2589	6115	173.42

Note: Figures in parentheses indicate the percentage of the total area

Table 4:Cropping pattern.

Year	Area under crops(in percentage)													Total cropped area(000,ha.)
	Paddy	Jowar	Maize	Pearl-millet	Wheat	Barley	Chick pea	Other pulses	Groundnut	Rapeseed &mustard	Cotton	Sugar cane	Vegetables	
1980-81	8.86	2.51	1.30	15.93	27.08	2.28	13.22	1.33	0.11	5.48	5.79	2.07	0.71	5462
1981-82	8.66	2.02	1.20	14.62	26.81	2.06	17.97	1.52	0.14	3.48	5.66	2.50	0.71	5826
1982-83	9.22	2.18	1.06	14.67	32.48	1.55	9.59	0.98	0.14	3.06	7.48	2.77	0.68	5306
1983-84	9.85	2.67	0.95	14.76	31.52	1.32	11.39	1.27	0.12	3.44	7.12	2.33	0.60	5688
1984-85	10.11	2.78	1.12	13.58	32.93	1.22	11.28	1.28	0.15	5.82	5.34	2.10	0.78	5512
1985-86	10.43	2.06	0.98	11.59	30.37	1.56	13.58	1.52	0.18	6.48	6.14	1.86	0.81	5601
1986-87	11.09	2.67	0.96	13.67	31.48	1.22	10.79	1.20	0.12	5.01	6.72	2.21	0.67	5662
1987-88	9.91	2.86	0.87	10.34	36.94	1.33	4.27	1.39	0.12	6.97	8.88	3.04	1.01	4686
1988-89	10.01	2.57	0.72	13.07	30.39	1.06	10.73	1.38	0.05	6.37	7.20	2.17	0.71	6012
1989-90	11.35	1.82	0.73	11.10	32.86	0.91	9.30	1.38	0.04	7.74	8.34	2.42	0.82	5651
1990-91	11.17	2.19	0.59	10.28	31.26	0.85	10.97	1.57	0.04	8.00	8.29	2.50	0.73	5919
1991-92	11.44	1.84	0.52	9.98	32.42	1.01	5.51	1.08	0.04	11.45	9.08	2.91	0.86	5570
1992-93	12.09	2.02	0.53	10.87	33.54	0.90	6.63	0.94	0.04	9.60	9.10	2.36	0.66	5883
1993-94	12.98	1.55	0.51	8.74	34.28	0.66	6.97	0.91	0.04	9.91	9.68	1.92	0.77	5815
1994-95	13.29	1.84	0.45	9.50	33.15	0.83	6.71	0.94	0.04	9.67	9.29	1.98	0.66	5989
1995-96	13.89	2.11	0.43	9.63	33.01	0.68	6.31	0.89	0.04	9.62	10.91	2.40	0.67	5974
1996-97	13.67	2.12	0.42	9.39	33.21	0.56	5.68	0.82	0.03	10.09	10.74	2.67	0.66	6074
1997-98	14.75	2.11	0.42	9.43	33.21	0.68	5.71	0.79	0.03	8.97	10.20	2.28	0.68	6143
1998-99	17.18	2.05	0.31	9.69	34.62	0.57	5.64	0.28	0.01	7.88	9.22	2.02	0.71	6320
1999-00	17.96	1.85	0.33	9.73	38.42	0.58	1.66	0.23	0.01	7.46	9.01	2.26	0.65	6029
2000-01	17.24	1.79	0.25	9.94	38.50	0.72	2.03	0.31	0.05	6.68	9.08	2.33	0.69	6115

Note: crops with negligible share in the total cropped area were excluded

Table 5: Irrigated area of important crops.

Year	Irrigated area of major crops(in percentage)						Total area irrigated to net sown area(%)	Net sow area (000.ha
	Paddy	Pearl millet	Wheat	Chickpea	Cotton	Sugarcane		
1980-81	97.13	11.84	93.10	43.08	98.29	91.07	59.20	3602
1981-82	95.72	13.50	92.96	32.10	98.03	89.59	61.40	3660
1982-83	98.26	15.93	94.02	41.27	97.38	92.39	65.50	3596
1983-84	90.79	14.42	95.62	26.25	96.47	91.18	60.80	3600
1984-85	98.33	11.63	95.40	20.11	97.76	92.24	60.50	3616
1985-86	98.80	12.93	96.33	25.10	99.97	95.01	62.20	3613
1986-87	98.73	15.36	97.98	33.88	99.29	95.62	64.80	3622
1987-88	99.50	27.33	97.54	65.43	98.94	94.87	79.80	3233
1988-89	98.89	13.87	97.83	21.07	99.28	95.64	71.00	3564
1989-90	99.30	21.20	97.56	29.86	99.45	96.42	73.90	3593
1990-91	99.02	15.45	97.87	21.72	99.47	96.08	72.90	3575
1991-92	99.51	19.04	98.13	28.69	99.64	96.36	76.00	3508
1992-93	99.57	17.45	97.91	22.94	99.62	96.34	75.30	3492
1993-94	99.60	19.68	98.19	20.49	99.64	96.43	75.80	3513
1994-95	99.62	15.29	98.39	20.00	99.64	96.43	76.40	3559
1995-96	99.28	17.74	98.33	18.57	99.34	97.22	77.30	3586
1996-97	99.63	15.59	98.31	18.84	99.24	98.15	76.50	3615
1997-98	99.59	17.45	98.29	14.98	98.94	97.59	76.80	3635
1998-99	99.81	18.43	98.18	13.73	99.14	98.43	78.30	3628
1999-00	99.83	19.60	98.77	42.82	99.50	98.02	81.30	3552
2000-01	99.78	24.16	99.11	32.93	99.74	97.90	83.90	3526

Table 6.Consumption of agro-chemicals.

Year	Fertilizers (kg/ha.)				Pesticides (kg/litre/ha.)
	Nitrogen	Phosphorous	Potash	Total	
1980-81	52.02	8.70	3.36	64.08	0.060
1981-82	59.06	8.85	2.95	70.86	0.062
1982-83	60.12	10.38	2.70	73.20	0.073
1983-84	72.09	14.73	3.80	90.62	0.076
1984-85	75.43	15.55	2.11	93.09	0.086
1985-86	82.04	19.27	1.70	103.01	0.100
1986-87	90.29	22.63	1.61	114.53	0.110
1987-88	93.01	27.32	1.51	121.84	0.114
1988-89	107.63	33.56	1.67	142.86	0.125
1989-90	112.05	35.92	1.06	149.03	0.132
1990-91	125.32	39.02	1.42	165.76	0.147
1991-92	132.47	40.31	0.72	173.50	0.150
1992-93	132.47	40.31	0.72	173.50	0.149
1993-94	149.93	42.51	0.70	193.14	0.148
1994-95	159.38	42.24	0.75	202.37	0.143
1995-96	164.94	37.53	0.89	203.36	0.142
1996-97	172.66	38.81	0.86	212.33	0.139
1997-98	182.30	47.25	1.09	230.64	0.138
1998-99	184.78	62.35	1.43	248.56	0.139
1999-00	201.10	58.08	2.72	261.90	0.141
2000-01	202.58	58.51	2.74	263.83	0.142

Table 7: Existing and suggested crop plan.

(000.,ha.)

Crop	Existing plan	Existing optimal plan	Suggested optimal plans		
			I	II	III
Paddy	1074.26	1078.02	966.83	963.12	918.41
Pearl millet	602.28	509.63	496.35	498.21	498.04
Maize	18.24	107.13	59.86	-	
Wheat	2286.19	2171.30	2002.57	1943.27	1869.49
Barley	38.34	-	-	-	
Chickpea	294.18	294.18	329.87	343.42	365.41
Rapeseed	452.08	615.18	630.21	645.03	654.08
Cotton	560.38	560.38	514.71	500.33	498.37
Sugarcane	135.46	135.46	135.46	135.46	135.46
Potato	14.08	14.08	61.08	81.37	98.0
Red gram			72.23	92.07	110.3
Green gram	-	-	62.24	86.78	103.8
Soybean		-	82.94	112.56	126.1

Lentil	-	-	58.14	71.78	97.8

Table 8: Existing and suggested crop plan.

(000,ha.)

Crop	Existing plan	Existing optimal plan	Suggested optimal plans		
			I	II	III
Water use(metre hectare)	2857.92	2855.68	2694.39	2670.78	2612.71
Fertilizers (kg)	1206851.69	1197415.81	1131430.39	1108790.24	1087700.98
Nitrogen(kg)	671504.78	666720.30	624296.35	609572.35	596503.85
Phosphorous(kg)	296444.51	294277.71	288387.84	286677.70	284214.93
Potash (kg)	238902.40	236417.80	218746.20	212540.19	206982.20
Pesticides(kg/litre)	3217.68	3343.52	3338.36	3336.14	3342.81

Table 9 : Saving benefit accrued.

(000,Rs.)

Crop	Existing optimal plan	Suggested optimal plans		
		I	II	III
Water use	4412.80	322154.10	368665.80	483063.70
Fertilizers	91835.85	678827.03	877789.31	1069169.65
Nitrogen	45739.63	451312.59	592074.03	717008.89
Phosphorous	33325.38	123911.58	150213.53	188090.94
Potash	12770.84	103602.86	135501.75	164069.82
Pesticides	-27443.12	-26308.24	-25024.28	-27278.34
Total	68805.53	974672.89	1221430.83	1524955.01

Table 10:Changing pattern of returns

(000,Rs.)

Crop	Existing plan	Existing optimal plan	Suggested optimal plans		
			I	II	III
Gross returns(crops)	105311422.80	104948059.90 (99.65)	104323393.00 (99.06)	103710367.60 (98.47)	103621184.70 (98.39)
Saving benefits (Water+ fertilizers +pesticides)	-	68805.53	974672.89	1221430.83	1524955.01
Gross return+ saving benefits	105311422.80 (100.00)	105016865.43 (99.72)	104298065.89 (99.03)	104931798.43 (99.63)	105146139.71 (99.84)

Note : Figures in parentheses indicate change over the existing plan.

PARTICIPATIVE APPROACHES TO ENHANCE ADOPTION OF FASCIOLOSIS CONTROL STRATEGIES IN CATTLE, IN YOGYAKARTA PROVINCE, INDONESIA

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ABSTRACT

Fasciolosis is a widespread, significant, endemic problem in cattle in rice-growing areas of Indonesia. Its effects are usually sub-clinical so it remains largely unrecognised by farmers and extensionists. Indonesian and Australian parasitologists have developed a suite of control strategies. Initial attempts to promote these strategies through Transfer of Technology (TOT) approaches achieved increased awareness, but little lasting change in farmer practices was evident 4 years later. This paper reports on the process, and early promising results from, an initiative to trial a Participatory Action Research (PAR) methodology to stimulate an extension process whose outcome is effective, sustainable fasciolosis control in Yogyakarta Province, Indonesia. In PAR, groups of farmers, extension agents and scientists work closely in a cooperative and flexible process, to resolve commonly identified problematic issues. The emphasis is on working with rather than for people through an interactive process to enhance opportunities for learning by doing. The process involved working through a four-step process to gain credible access to four farmer groups in three villages identified as having a fasciolosis problem. This was followed by a 9-month long series of activities, coordinated through farmer group meetings, which included (1) creating awareness through developing a media package, and then maintaining farmer involvement through (2) design and execution of field trials, (3) monitoring results, and (4) presentation and discussion of results with farmers. Group meetings were an important part of the information exchange process, and the use of learning aid tools was regarded as complementary for interpersonal communication.

Of the four recommended control strategies, two were already practised for reasons other than fasciolosis control, one was acceptable but had prohibitive cost, and the fourth was unattractive because it was technically difficult to implement. A significant development was a new strategy generated within a farmer group that was adopted readily by other groups. We conclude that adoption of technical innovations by farmers depends largely on two issues: (i) the nature of the associated farming systems, and (ii) the way in which the innovation is presented through extension agency activity. A participative approach appears to have considerable potential for stimulating significant practice change, particularly if it incorporates farmer involvement in generation and dissemination of locally relevant knowledge and recommendations. PAR fosters such a reflexive approach.

Key words: Fasciolosis control, participatory action research, adoption process

INTRODUCTION

Fasciolosis is a common disease in cattle and other ruminants caused by parasite Fasciola gigantica known as liver fluke. The disease is widespread in South East Asia and many other humid tropical regions. Roberts and Suhardono (1996) identified the highest prevalence of fasciolosis in cattle and buffaloes in Indonesia associated with production of irrigated rice. It reduces draft, production and reproductive efficiency of cattle and buffalo due to poor feed conversion, and has a debilitating effect on animals. It also contributes to liver condemnation. The distribution of F.gigantica depends on the presence of an intermediate host, Lymnaea rubiginosa in irrigated rice fields (Suhardono et. al., 1988; Estuningsih and Copeman, 1996; Widjajanti, 1998)

Fasciolosis is mostly chronic and subclinical, so production losses are hard to observe. Consequently, little control is practised because the lower level of weight gain, reproductive rate and draught output is largely unrecognized by farmers.

A set of strategies for fasciolosis control in cattle and buffaloes, in areas where irrigated rice is grown extensively, was developed in West Java by a team comprised of parasitologists from the Research Institute for Veterinary Science (Balitvet) in Java, and James Cook University in Australia, supported by ACIAR Project 9123. These strategies were reported by Suhardono et al. (1998):

Strategy 1: Grazing control. Prevent animals grazing in the rice field adjacent to a village or cattle pen for up to a month after harvest, to reduce their risk of ingesting metacercariae.

Strategy 2: Feeding control. Feed only the top two-thirds of freshly cut rice stalks, cut 20-30 cm above water level, to avoid feeding metacercariae, and dry the lower third of the straw in sunlight for 3 days before feeding.

Strategy 3: Biological control. Before using cattle dung as fertiliser in the rice fields, mix it with duck or chicken manure naturally infected with Echinostoma revolutum, or build the duck/ chicken pen side by side with the cattle pen.

Strategy 4: Chemical control. A single anthelmintic treatment with Triclabendazole given one month after the end of the last regional harvest in the dry season.

A pilot extension program to introduce fasciolosis control strategies to farmers was first conducted in Surade, West Java in 1996 (Martindah, et. al., 1998). It also provided a test of suitable extension methodology. The pilot showed that the Transfer of Technology (TOT) technique created awareness among respondents. The villagers then conducted intuitive cost-benefit analysis and agreed to adopt 2 of the 4 strategies. However, an evaluation four years later of longer-term benefits in terms of both sustained reduction in the level of infection and retention of knowledge on control, found there was little adoption evident (Martindah, et. al., 2000). This is consistent with Blacket (1996), who said that the TOT model can create awareness of an issue, but this awareness does not easily translate into understanding or change. Frank (1995) notes that farmers will listen politely to the advice of visiting agents and disregard it, because the costs they perceive will exceed perceived benefits.

From the previous experience, and with extension input from University of Queensland, we learned that effective extension is not about transfer of technologies, it is about developing human and social capital (knowledge, understanding, motivation, skill, attitudes, behaviour) for individual and community to implement and maintain activities (Uphoff, 1999). To promote sustainability of fasciolosis control strategies, we stepped away from the traditional linear concept of technology transfer. In its place we developed a participatory approach, in which farmers could learn to identify problems that limit their productivity in close collaboration with field extension workers and research scientists.

Participatory Action Research (PAR) combines research to understand the problem situation with action to improve it using a cyclic process which alternates between action and critical reflection (Dick, 1999). PAR involves farmers in the research process, the aim is to foster a collaborative research process (Cornwall and Jewkes, 1995). It means that farmers become directly involved in research that is appropriate to their needs. Group meetings are an important part of the information exchange process. Emphasis of the participatory approach is on working with people rather than working for people. Extension is most effective when it is participative through an interactive process, if potential user (farmers) and extension agent are able to interact with researchers to enhance opportunities for learning by doing (Knowles, 1990). The Participative Action Model (PAM) (Chamala, 1995), for example, describes criteria for effective partnership between people at different hierarchical levels in cooperating organisations, in order to negotiate desirable change.In this situation, extension agents had a difficult task creating an awareness of fasciolosis in the target group, as the problem and its consequences are not clearly visible. In light of the ineffectiveness of TOT in stimulating long-term change in understanding and behaviour, a revision was required. Consequently, two objectives were formulated:

To revise the fasciolosis extension program used in Surade, for conduct in Yogyakarta province using a participatory approach, to give farmers and other stakeholders a greater sense of involvement.

This was to be achieved through encouraging and enabling key stakeholders to work together in a cooperative and flexible social process to facilitate awareness, consideration and implementation of the four fasciolosis control strategies.

To use this situation to develop and test a suitable extension approach for introducing fasciolosis control strategies that are consistent with established farming systems in other parts of Indonesia.

Methoology

Participative Action Research uses qualitative techniques that emphasise the search for meaning in context rather than numerically measured data (Anderson & Poole, 1994). The qualitative data in this study is derived from joint use of a semi-structured questionnaires and interviews, field observations and field notes. The steps taken in the PAR process were as follows:

Development of a promotional package

Gaining provincial and district endorsement

Conducting a collaborative workshop and co-ordination meeting

Purposive selection of village field sites

Conducting a series of farmer meetings over an extended period (9 months)

These steps are elaborated below.

Development of a promotional package

In order to illustrate the symptoms and effects of fasciolosis, a media package was developed prior to early meetings, including:

A set of photos for display at each meeting, and for extension staff; showing damaged vs. normal livers, host snails, flukes and metacercaria.

An audio cassette in a local language describing the life cycle of the fluke and the strategies to control it.

Brochures and leaflets to create awareness and basic understanding of fasciolosis, for wide distribution to other farmer groups, the University library, and other institutions within Yogyakarta Province.

A booklet (Balitvet version) instead of a wall display to describe the epidemiology of fasciolosis in greater detail than the leaflets.

Gaining provincial and district endorsement

An official visit was made to the Provincial and District Livestock Offices in Yogyakarta Province to get endorsement to survey and identify locations where fasciolosis is endemic.

Workshop and Coordination meeting

In order for the fasciolosis control program to be sustained in the selected areas, the four strategies were introduced to a one-day workshop, where issues that might limit their implementation were negotiated and discussed. The workshop was divided into two sections:

A workshop on control of Fasciola gigantica informed and introduced four fasciolosis strategies that were closely associated with the rice farming system in Yogyakarta Province. Sixty participants attended this workshop including government officials from province to district level, extension workers, and farmer group leaders.

Coordination meeting: The 25 participants who attended the coordination meeting were all stakeholders who were expected to be involved directly or indirectly in the activities. The coordination meeting discussed the method of extending fasciolosis control by PAR and also negotiated a visit with each selected livestock village for conducting a benchmark study.

Purposive selection of village field sites

Three districts (Sleman, Bantul and Kulon Progo/Wates) were recommended which met the following criteria:

Rice growing area

High population of cattle

High prevalence of fasciolosis in cattle

Within these districts twelve ‘livestock villages’ were surveyed, showing that the prevalence of fasciolosis varied between 16% and 76%.

The selection process was ‘purposive’ in that it was primarily determined by the above criteria. Livestock villages were selected on the bases of a prevalence of fasciolosis exceeding 40%, and the extent to which farmers agreed to co-operate in the study. Four ‘livestock villages’ (groups) were selected for on-going extension activities (Table 1). This process of selection was also discussed with officers at Provincial and District Livestock Office levels, as well as with extension agents and representatives of the farmers from the survey areas. The intent of being ‘purposive’ was to focus extension program efforts on areas of greatest need, and to involve the farmers, thereby encouraging their commitment, support, and participation in planned activities.

Table 1. Farmer groups involved in control of fasciolosis, in Yogyakarta Province

District	Sub district (village)	Farmer group	No. of farmers	No. of cattle	Prevalence of fasciolosis
Sleman	**Mlati** (Cebongan-Tlogoadi)	G1: "Margo Bhakti"	18	34	47%
	Tempel (Tambak rejo)	G2: "Sidodadi & Lestari"	48	80	40%
Bantul	Bambanglipuro (Bondalem)	G3: "Manunggal Lestari"	24	40	72%
	Bambanglipuro (Tangkilan)	G4: "Andini Rejo"	33	80	52%

Since fasciolosis is not clearly visible, most participants wanted a field extension aid (brochure, leaflet), or a demonstration so they could learn about fasciolosis and its control strategies. This was a good start as part of a participatory process for sharing ideas amongst the participants. Information was gathered from direct observation combined with a benchmark study. The benchmark study used a semi-structured questionnaire to interview the farmers. The questions addressed the farmers' personal background and their knowledge about causes, symptoms, treatment of infection and feeding management.

Conducting a series of farmer meetings over an extended period (9 months)

(a) Awareness. A series of meeting were planned in each cooperating village over 9 months after the second harvest period. The first important stage of the village extension activities aimed to create an awareness of the problem. At the farmers meeting in each group, we distributed leaflets and demonstrated the cercariae and eggs of F.gigantica under a binocular microscope, as well as dried fluke and the host snail. It gave farmers and extension agents an opportunity to learn.

(b) Drugs trials. These were carried out in each livestock village, organised by District Livestock Officers together with extension agents and active participation of the farmer group members. Through these, extension agents and farmers in each group could learn to identify the problem through observation.

(c) Faecal sampling. Faecal samples were taken from 4 groups and examined for evidence of parasite infestation in the Laboratory of District Livestock Services.

(d) Presentation of results and discussion. The results were presented to each group at the farmers' meetings. Farmers then discussed the results and agreed to split the cattle that were positive for fasciola into two groups: control and treated. The farmers decided to observe those two groups for 1 month. Two people in each group were chosen as recorders, and 2 notebooks and pens were given to them to record their observation of control and treated groups.

Results

Rice-livestock Farming System

The benchmark study showed that farmer members of the 4 groups worked primarily in rice fields, whether on their own land or on others' as labourers; about 15% of them worked outside farming in varied occupations including school teachers, government officers, traders, and drivers. Keeping livestock (cattle) was not their main livelihood. The purpose of keeping cattle is as a form of saving, and animals are sold when farmers need cash. They keep only 1 or 2 cattle per household. About 40% of the farmers had more than 10 years experience in keeping cattle.

Results of the benchmark study indicated that farmers did not know about fasciolosis specifically; however, about 60% did know that cattle can be infected by worms, and that the source of infection is either grass (44%) or cattle dung (14%). Most farmers believed that cattle infected by worms lose their appetite, and their coats lose their shine. Once such symptoms occur they would ask a veterinarian or paramedic to give anthelminthic treatment.

Farmers' observations after treatment

In general, most farmers in the 4 groups realised that after one week of treatment, cattle in the treated groups were healthier than those in the control groups, in terms of increased feed consumption and better performance. They noted that 2 cattle in G1, and 3 cattle in G3 had diarrhoea on the 2nd day after treatment, but were recovering 3 days later.

Farmers in all 4 groups reported that they could not see the difference between untreated cattle, which tested positive to *Fasciola,* and cattle which tested negative. Consequently, farmers recording their observations of the untreated group said "no difference", "they were like normal cattle", or "as usual". The farmers' discussed their observations informally within each group and with others. Although the untreated cattle group seemed to look like normal cattle, the farmers had evidence of the better performance from the treated cattle. From this they concluded that when fasciolosis is present, ill thrift from the disease, although present, may not be clearly visible.

Consequently, most farmers, especially in G1, G2 and G3, requested anthelmintic (Triclabendazole) for the untreated cattle groups. One farmer (G2) with cattle in the untreated group asked veterinary services staff to treat his cattle soon after he realised that cattle in the treated group were getting better, rather than wait one month for the observation to finish. Owners of untreated cattle in G4 took 5 months to request such treatment, because they needed to discuss it amongst themselves, but rarely all attended the regular meetings together. Thus, the month-long group activities observing treated and untreated cattle stimulated most farmers to take action to resolve the problem.

Implementation of the Control strategies

Strategy 1: Grazing control.

This strategy was not relevant in the 4 livestock villages (farmer groups) because cattle are already normally kept in pens at all times. Therefore, no change in current practice was required. Cattle are coincidentally prevented from grazing in freshly harvested rice fields.

Strategy 2: Feed control.

The main feeding method for cattle is 'cut and carry' grass, with additional feed concentrates, provided to penned cattle. However, at harvest time most farmers also give the top part of fresh rice straw. Rice straw or other agricultural by-products are complementary to grass, which is grown along irrigation canals and along the dikes (*pematang*) between rice fields. Beside feeding grass and fresh straw, most farmers also stock dry rice straw. They dry the straw usually during the 2nd harvest time, in June/July, when there is enough sunshine, because the first harvest in March occurs in the rainy season. Farmers have developed the practice of using the top 2/3 of the straw for feeding, and removing the bottom part, because cattle do not like the bottom part and the farmers believe it is not nutritious. As with Strategy 1, current practice already complies with the recommendation. This means that two of the strategies to control fasciolosis were already, coincidentally, part of accepted management practice, for other reasons.

Strategy 3: Biological Control.

This strategy was more difficult for most farmers in all groups to adopt. As a tradition, farmers heap dung in the corner of or behind the cattle pens, for sale or use as fertiliser when it has dried. In the first planting season it is not used as fertiliser because it is hard work spreading the cattle dung onto irrigated rice fields when the land is wet and muddy. However, dung is used as fertiliser on dry (non-irrigated) land for peanuts, corn, watermelons and vegetable crops. It is also spread on the rice fields in October/November when preparing the land for rice. The practices of the rice-livestock farming system are shown in Figure 1.

Two farmers in G3 implemented the biological control strategy, then after 2 months another four farmers in this group followed them, keeping their ducks close to the cattle pens. The faeces of both species were mixed when the farmers swept the pen floors. This practice continued only for 4 months, however, because most of the ducks died after scavenging in a stream nearby, due to a poison ('potas') that is used to catch fish. They gave up keeping ducks, and did not want to substitute with chickens, because chickens around the cattle pens disturb the cattle.

Some farmers in G1 and G4 were also willing to keep ducks, but prevented from doing so by other farmers because ducks are likely to destroy rice plants in the fields. In contrast, through discussion among group members, farmers in G2 were uninterested in implementing this strategy because of the extra cost of building the pens, and buying the ducks or chickens. However, one G2 member was prepared to implement the strategy if he received some subsidy incentive to build the pen and stock it with ducks or chickens. The next G2 farmer meeting discussed this issue and it was agreed that incentives for this strategy could create jealousy amongst others. It was further agreed to refuse to allow ducks to scavenge in the rice fields unless they were herded, which effectively precluded this activity through lack of time. Farmers were sceptical as to whether it was worth investing their time and energy to implement this strategy, particularly if it offered little financial benefit or if there are considerable technical difficulties associated with its implementation.

However, the farmers themselves developed a modified biological control strategy that was more acceptable because of several advantages.

Strategy 3 (a) (Farmers' adaptation of strategy 3): Composting the cattle dung.
After the biological control strategy with ducks failed, the group leader and 2 members of G3 decided to make compost from the cattle dung. Their purpose was to cut the life cycle of F.gigantica as well as to make a better quality fertiliser. The idea was based on their knowledge that the fluke eggs hatch in 9-12 days, and that the process of composting takes 3 weeks and generates high temperatures. They concluded that high temperatures would kill any hatching larvae well before the compost was applied to rice fields.

This idea was discussed at several meetings of G3 because of the farmers' differing perceptions of advantages and disadvantages. Some argued that the sale of cattle dung was already profitable for them without composting. Then the G3 leader asked the extension agent to explain how to make compost and what material is needed.

Together, group members calculated a simple cost-benefit analysis. Without composting, the value of 400-kg cattle dung was estimated at Rp. 20,000. The cost to make 400-kg of composted dung was much higher, at Rp. 44,200, but it also should be valued much higher, at about Rp. 100, 000. Even though the farmers did not include the value of their labour and time spent in their calculation, they were all enthusiastic, as it appeared to be profitable.

Finally, the farmer group G3 agreed to make compost collectively as a demonstration, and negotiated how much dung was to be collected and returned as compost to the owner. When the compost was ready, the farmer leader conducted his own trial to compare compost and chemical fertiliser for growing corn. He observed that corn with compost was growing better than corn with chemical fertiliser and he showed his trial to the group members. Consequently, the group members were making compost for use on their own land.

Since the farmer group G3 succeeded, through an interactive process, to make compost, we negotiated with the farmers and extension agents to share their knowledge with the other groups, especially G1 and G4. Interested farmers from G1 and G4 as well as the extension agents and veterinary services responsible to those groups were invited to attend a farmer meeting in G3. They had a warm informal discussion, exchanged experiences and shared knowledge about what they could and could not do to control fasciolosis.

Strategy 4: Chemical control.

Most farmers in all four livestock villages accepted this strategy. Farmers decided to adopt drenching with Triclabendazole one month after the 2nd harvest period. However, prohibitive cost made this option unlikely to be adopted unless the cost was subsidised in some way.

Finalisation of fieldwork (first cycle)

To mark the end of this cycle of fieldwork, the progress of the fasciolosis control strategies was discussed at a special farmer meeting called to promote active reflection on the activities and their outcomes. A major output was a calendar of practice to guide implementation of the strategies as an action plan, made according to their own timelines, the local weather patterns, and rice-livestock farming activities.

Discussion and Conclusion

The extension process began with acceptance of a problem by researchers, who recognised that they needed assistance in extension in order to achieve adoption of the strategies they had developed, since a TOT approach had been found to be unsuitable in the Surade work. Consequently, a participatory approach was adopted. In this approach, groups of farmers, extension agents and researchers worked closely to create and share information to reach a common and better understanding of the problem (Guerin and Guerin, 1994). The participative approach focused on collaboration with all relevant stakeholders. Participants were actively involved in a learning-by-doing exercise, which generated intrinsic motivation among all stakeholders: extension agents, researchers, veterinary services and farmers.

Hawkins et al. (1982) suggest that to work successfully with farmers, extension agents must respect farmers' skill and knowledge, and adjust to the farmers' situation. The relevance of the process to the local farming system was illustrated by the way farmers adapted strategies, for example composting and feeding upper stems for nutritional advantages. Such activities provide a learning situation through interactive process to allow and encourage every one in the group to participate. As the Transfer of Technology model had proved to be an inappropriate concept for fasciolosis control in this situation, the PAR (participatory action research) approach was chosen to improve participation of the farmers through active involvement in planning and implementation. The length of the decision process to implement fasciolosis control strategies varied between groups. Depending on the individuals' initial awareness, the decision to adopt could be immediate or take several months.

We concluded that farmers learn most and best from their experience, through an interactive learning process to help people understand their problem situation. Group meetings enable an interactive method of learning, and the use of learning aids helps interpersonal communication. However, the process that leads to a decision to implement fasciolosis control strategies depends on individual awareness and need. This need varied between and within groups.

With respect to the two research project objectives, we concluded that (1) the successful revision of the original extension approach had been largely achieved, and (2) there was considerable potential for this more participatory approach to be applied, with locally relevant modifications, in other situations.

The longer-term outcomes of this project continue under review in subsequent PAR cycles.

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