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Improved Farm Technology Adoption and its Role in Doubling Farmers' Income: A Case of Dry Zones in Karnataka§

V.R. Kiresur[a]*, Mahantesh R. Nayak[a], G.M. Gaddi[b] and Kashibai S. Khyadagi[a]

[a]University of Agricultural Sciences, Dharwad-580 005, Karnataka
[b]University of Agricultural Sciences, Bengaluru-560 065, Karnataka

Abstract

The study has estimated the adoption of improved dry farming technologies, identified the factors governing their adoption and assessed the socio-economic impact owing to their adoption, including enhancement in farm incomes. The study is largely based on the primary data collected from a sample of 500 farm households spread across 50 villages chosen from 25 talukas in all the five dry zones of Karnataka. Technology Adoption Index (TAI), multiple regression model and descriptive statistics were used to analyse the data. The TAI was found highest in the Improved Livestock Management Practices (ILMP), followed by Improved Crop Production Technologies (ICPT), Improved Energy Management Systems (IEMS) and Improved Soil and Water Conservation Technologies (ISWCT), and was least in Improved Land Use Systems (ILUS). Due to adoption of improved dry land technologies, across all dry zones, the average increase was 21.37 per cent in resource-use efficiency, 22.75 per cent in profitability, 14.96 per cent in standard of living, 13.50 per cent in women's participation and 8.19 per cent in reduction of women's drudgery. Given the technology adoption levels much below the desired levels, the extension gap (Yield Gap-II) needs to be more focussed than research gap (Yield Gap-I) in the next 4-5 years. To achieve "doubling of farmers' income by 2022", a multi-pronged approach needs to be adopted by all concerned in a consistent and planned manner, since the contributions to double the farm incomes come not only from technological innovations, but also significantly from institutional support, infrastructural facilitation and policy intervention.

Key words: Improved technology, doubling farmers' income, dry zones, Karnataka

JEL Classification: Q12, Q16

Introduction

India will have to produce around 300 million tonnes of food grains to feed her population by 2025 AD. This target cannot be realized from the irrigated areas alone as the irrigation potential is for 178 million hectares and is a function of rainfall received. The gap between irrigated and dryland agriculture has steadily widened, with the productivity of the latter being less than half of the former. Dryland agriculture emerges as the biggest drag on the growth of the economy. Nonetheless, even at their low productivity levels, the quantitative significance of dryland agriculture is by no means small (Shah *et al.*, 1998). It is more appropriate to view the drylands as a source for future growth, a hidden potential waiting to be unlocked. The rainfed areas suffer from bio-physical and socio-economic constraints, affecting the productivity of crops and livestock (Venkateswarlu, 2011). Even in

* Author for correspondence
Email: kiresur_vr@yahoo.co.in

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the most optimistic scenario of further irrigation development in India, nearly 40 per cent of national demand for food in 2020 will have to be met through increasing the productivity of rainfed/dryland agriculture (Samaj Pragati Sahayog, 2006).

The drylands are caught in a low-level equilibrium trap. The second green revolution in Indian agriculture should usurp rainfed/dryland agriculture since the first green revolution bypassed it. We need not only viable agriculture packages but also meticulously worked out land-use planning systems, which make careful use of available soil moisture through appropriate tree-crop mixes. Another crucial area of neglect is livestock. Ownership of livestock has a crucial drought-cushioning role for small and marginal farmers. In spite of the vital role of livestock in a rural household, strategies of improving livestock productivity and health have not been systematically integrated as central interventions in the drylands.

The business as usual approach of taking all the major interventions uniformly across all the regions of the country has not paid much dividend. Thus, regionally differentiated interventions befitting natural resource endowment and livelihood status are urgently needed to meet the local challenges and enhance livelihoods. In Karnataka, among the different resources available under dryland condition, land resource is important in order to sustain the crop productivity. Out of the ten agro-climatic zones in Karnataka state, five are classified as dry zones, viz., North Eastern Dry Zone (Zone-2), Northern Dry Zone (Zone-3), Central Dry Zone (Zone-4), Eastern Dry Zone (Zone-5) and Southern Dry Zone (Zone-6). What is the level of adoption of improved dry farming technologies, and what is the impact of technology adoption in terms of profitability, resource-use efficiency and standard of living of farm households? These are some of the research questions that the present study has tried to address.

Data and Methodology

Using multistage stratified random sampling, the study has covered all the five dry zones of Karnataka. From each Zone, five talukas, from each taluka, two villages and from each village, 10 farm households were chosen randomly. Thus, 500 farm households spread across 50 villages constituted the study sample.

The study relied mainly on the primary data collected from the rural households of the study area using a well-designed and pre-tested schedule. In addition, participatory rural appraisal (PRA) tools were also used. The data collected included variables on the extent of adoption of improved farm technologies, advantages/constraints in adoption, impact of major technologies in terms of income, employment and livelihood options, resource utilisation and conservation, among others.

Analytical Tools

Technology Adoption Index for estimating the extent of adoption of dryland technologies by the farmers and multiple regression models for identifying the factors responsible for technology adoption were used in the present study. Descriptive statistics were used for assessing the impact of selected technologies adopted by the farmers and also for identifying and suggesting suitable technological, institutional and policy interventions that could help upscale the technology adoption levels, promote efficient resource use and enhance the socio-economic impact.

Results and Discussion

Adoption Status of Improved Technologies

Improved Soil and Water Management Techniques

Table 1 presents the adoption status of improved soil and water management techniques. It was observed that under the terrace level practices, the overall complete adoption was highest in contour bund (69.4%), followed by broad based bund (49%), graded bund (31.2%), and contour border stripes (22.4%). Ramasubramanian (2003) has reported that only 30 per cent of the dryland farmers adopted contour bunding. The majority of dryland farmers (76%) had adopted contour cultivation (Prasad *et al*., 2000). In contour bund technology, the complete adoption varied from 35 per cent in Zone-2 to 97 per cent in Zone-6. Similarly, in the case of inter-terrace level practices, fall ploughing recorded the highest complete adoption (70.6%), followed by ridges and furrows (58%) and vegetative live barriers (21.6%). Across all the zones, complete adoption of fall ploughing ranged from 22 per cent in Zone-3 to 77 per cent in Zone-6. Thangaraja *et al*. (2005) have reported that the majority of dryland

Table 1. Adoption status of improved soil and water management techniques

(Per cent)

Technology	Zone-2			Zone-3			Zone-4			Zone-5			Zone-6			Overall		
	C*	P*	N*	C	P	N	C	P	N	C	P	N	C	P	N	C	P	N
Terrace level practices																		
Contour bund	35	5	60	45	7	48	78	5	17	97		3	92	1	7	69.40	3.60	27.00
Contour ditch	14	3	83	7	7	86	19	3	78	13	19	68	12	24	64	13.00	11.20	75.80
Graded bund	34	3	63	53	10	37	25	5	70	16	16	68	28	7	65	31.20	8.20	60.60
Broad based bund	73	6	21	46	7	47	49	7	44	40	6	54	37	9	54	49.00	7.00	44.00
Contour border strips	27	3	70	13	8	79	18	6	76	19	14	67	35	11	54	22.40	8.40	69.20
Graded border strips	17	5	78	5	5	90	8	1	91	10	7	83	9	10	81	9.80	5.60	84.60
Zingg Cons. Bench terrace	9	3	88	6	2	92	7		93	4	11	85	3	5	92	5.80	4.20	90.00
Inter terrace level practices																		
Fall ploughing	51	4	45	60	22	18	84	3	13	81	4	15	77	10	13	70.60	8.60	20.80
Tied ridging	18	1	81	16	8	76	10	5	85	10	17	73	15	9	76	13.80	8.00	78.20
Ridges & furrows	50	6	44	58	17	25	61	13	26	59	2	39	62	8	30	58.00	9.20	32.80
Cultivation across slope	21	8	71	17	6	77	14	4	82	16	14	70	9	11	80	15.40	8.60	76.00
Vegetative live barriers	19	8	73	16	3	81	26	2	72	32	14	54	15	7	78	21.60	6.80	71.60
Compartmental bunding	5	4	91	9	1	90	6	1	93	18	11	71	20	2	78	11.60	3.80	84.60
Vertical mulching	2	1	97	2	2	96	6	1	93	3	15	82	1	8	91	2.80	5.40	91.80
Surface mulching	2	2	96	1	1	98	8	4	88	5	12	83		8	92	3.20	5.40	91.40
Green manuring	10	10	80	19	5	76	26	18	56	22	12	66	15	9	76	18.40	10.80	70.80
Water harvesting structures																		
Farm ponds	35	7	58	13	1	86	24		76	30	7	63	29	8	63	26.20	4.60	69.20
Percolation tanks	4	3	93	2	2	96	3	1	96	9	8	83	3	16	81	4.20	6.00	89.80
Nala bunds	26	4	70	12	5	83	21	2	77	31	14	55	47	3	50	27.40	5.60	67.00
Check dams	5	4	91	3	1	96	16	2	82	19	8	73	18	7	75	12.20	4.40	83.40
Ravine reclamation structures		3	97		1	99	1	1	98	4	12	84	6	7	87	2.20	4.80	93.00
Underground check dams	4	3	93	3		97	3		97	10	6	84	5	5	90	5.00	2.80	92.20
Vented check dams	2	1	97			100			100	4	12	84	6	3	91	2.40	3.20	94.40
Water surplussing & grade stabilization structures																		
Gully plugging	1	1	98	1		99	8	6	86	25	5	70	32	4	64	13.40	3.20	83.40
Drop structures	3	2	95			100	4	3	93	2	19	79	5	11	84	2.80	7.00	90.20
Brushwood dams		4	96			100			100	4	8	88	3	2	95	1.40	2.80	95.80
Gabion structures	1		99			100			100	7	11	82	2	9	89	2.00	4.00	94.00
Sand bags	1		99			100	1	4	95	4	10	86	2		98	1.60	2.80	95.60
Water ways	78	14	8	32	3	65	35		65	73	5	22	74	6	20	58.40	5.60	36.00

Note: *C=Complete adoption; P=Partial adoption; N=Non-adoption farmers practised summer ploughing and farmyard manure application. In the water harvesting structures, the complete adoption was highest in nala bunds (27.40%). Similarly, among water surplussing and grade stabilizing structures, the complete adoption was recorded highest in water ways (58.4%), ranging from 32 per cent in Zone-3 to 78 per cent in Zone-2. Among these, complete adoption of water ways was 58.4 per cent followed by gully ploughing (13.4%). The critical dryland technologies like contour bunding, farm pond construction exhibited poor adoption rate (Lavanya and Anamica, 2013).

Improved Crop Production Technologies

The adoption status of various improved crop production technologies such as crop management practices, soil health and nutrient management and plant protection and irrigation (Table 2) reveals that among different crop management practices, high-yielding varieties or hybrids did show maximum complete adoption (83%), followed by use of short-duration varieties (80%) and use of drought-tolerant varieties (78%) across all the dry zones. The majority of farmers (88%) did not use the recommended quantities of chemical fertilizers, whereas 97 per cent of farmers adopted the practice of recommended time of sowing (Prasad *et al.*, 2000). This high-yielding variety technology's complete adoption range varied from 61 per cent in Zone-4 to 95 per cent in Zone-6.

Similarly, in the case of soil health and nutrient management practices, the recommended dose of nitrogen fertilizers (95.4%) witnessed the highest complete adoption, followed by phosphorus fertilizers (95.2%), across all the zones. The adoption status of recommended dose of nitrogen fertilizer varied from 91 per cent in Zone-6 to 99 per cent in Zone-4. The pest management using pesticides was adopted completely by around 85 per cent of the sample respondents, followed by recommended frequency of irrigation (32%). The pest management showed a range from 73 per cent in Zone-5 to 97 per cent in Zone-2. The use of bio-fertilizers was not common even among the sustainable agriculture group of farmers. The adoption of improved crop management technologies will result in dividends in terms of profitability even under vagaries and uncertainties of rainfall (Babu and Murthy, 2005).

Improved Livestock Management Practices for Cattle and Buffalo

Table 3 presents the adoption status of improved livestock management practices for cattle and buffalo. It reveals that among different cattle-related improved technologies across all the dry zones, feeding management recorded highest complete adoption (81.45%), followed by housing management (80.65%) and vaccination (60.08%). About 54 per cent farmers fed their cattle with concentrate feed, but the recommended ration was not given (Sathiadhas *et al.*, 2003). Only 7.8 per cent of the farmers fed their cows with the recommended quality of feed, 33.3 per cent fed improved feed (concentrate mixed) and around 59 per cent fed their cattle in the traditional way (Quddus, 2012). The complete adoption of feeding management varied with a wide range of 68.6 per cent in Zone-3 to 91.3 per cent in Zone-6. However, in the case of non-adoption of technologies, meat and meat products and marketing occupied the first position (99.60%), followed by record keeping (90.32%), value addition to livestock wastes (86.69%) and credit/loan/subsidy schemes (86.69%), across all the zones. An improvement in the feeding system could be an important pre-requisite for increasing profitability of dairy production since the cost of feeding accounts for about 40-60 per cent (Devendra, 2002; Man, 2001) of the total cost of milk production.

The adoption status of improved livestock management practices for buffalo revealed that, across all the dry zones, feeding management recorded the highest complete adoption (76.7%) followed by vaccination (68.49 %) and housing management (64.4%). Aulakh and Singh (2012) have reported high adoption in the case of adequate supply of feed and water to the buffalo (95.0%), followed by udder cleaning (90.6%) and keeping of buffalo in a ventilated house (82.22%). The proper vaccination programme was adopted by 95 per cent of the buffalo farmers (Binwad *et al.*, 2007). The complete adoption of feeding management by respondents was practised by about 67 per cent in both Zone-6 as well as Zone-4 to about 86 per cent in Zone-2. However, in the case of non-adoption of technologies by respondents across all the zones, meat and meat product preparation and marketing recorded the highest (98.6%), followed by insurance scheme and record keeping (95.9% and 94.5%, respectively).

Table 2. Adoption status of improved crop production technologies/ practices

(Per cent)

Technology	Zone-2			Zone-3			Zone-4			Zone-5			Zone-6			Overall		
	C*	P*	N*	C	P	N	C	P	N	C	P	N	C	P	N	C	P	N
Crop management practices																		
Use of HYVs/Hybrids	94		6	82	6	12	61	36	3	85	2	13	95		5	83.40	8.80	7.80
Use of short-duration varieties	89	5	6	81	9	10	80	10	10	62	21	17	86	14		79.60	11.80	8.60
Use of drought-tolerant verities	83	9	8	86	9	5	77	12	11	65	25	10	81	19		78.40	14.80	6.80
Seed hardening	6	88	6	22	67	11	5	77	18	11	70	19	6	79	15	10.00	76.20	13.80
Seed rate	79	12	9	85	3	12	65	13	22	67	18	15	59	21	20	71.00	13.40	15.60
Date of sowing	74	11	15	86	6	8	63	8	29	69	13	18	73	11	16	73.00	9.80	17.20
Spacing	65	19	16	77	10	13	72	8	20	63	19	18	64	21	15	68.20	15.40	16.40
Dry seeding	14	75	11	10	85	5	9	86	5	10	72	18	15	72	13	11.60	78.00	10.40
Deep intercultivation	32	53	15	29	47	24	9	71	20	7	71	22	12	69	19	17.80	62.20	20.00
Improved implements	17	66	17	29	30	41	9	73	18	14	72	14	14	66	20	16.60	61.40	22.00
Inter cropping	38	45	17	51	31	18	11	72	17	5	76	19	12	78	10	23.40	60.40	16.20
Mixed cropping	27	57	16	12	76	12	10	82	8	25	62	13	10	72	18	16.80	69.80	13.40
Crop rotation	67	22	11	79	15	6	18	68	14	30	55	15	18	74	8	42.40	46.80	10.80
Mid-season correction	1	99		9	89	2	3	89	8	4	82	14	3	91	6	4.00	90.00	6.00
Mechanized threshing	5	88	7	22	71	7	1	96	3	3	93	4	4	86	10	7.00	86.80	6.20
Soil health & nutrient management																		
Rec.dose of N' fertilizer	98		2	92	5	3	99	1		97	3		91	4	5	95.40	2.60	2.00
Rec.dose of P' fertilizer	96		4	93	6	1	95		5	98	1	1	94	2	4	95.20	1.80	3.00
Rec.dose of K' fertilizer	87		13	95	3	2	86	1	13	78	5	17	88	6	6	86.80	3.00	10.20
Rec.dose of manures	75	9	16	50	24	26	35	24	41	63	25	12	49	34	17	54.40	23.20	22.40
Rec.dose of bio-fertizers	4	88	8	9	81	10	6	83	11	8	75	17	7	84	9	6.80	82.20	11.00
Rec.dose of gypsum	5	83	12	45	45	10	5	80	15	3	86	11	10	81	9	13.60	75.00	11.40
Timely application of fertizers	17	42	41	95	3	2	19	38	43	5	94	1	8	91	1	28.80	53.60	17.60
Plant protection & irrigation																		
Pest management-Pesticides	97	1	2	84	12	4	86	2	12	73	17	10	86	7	7	85.20	7.80	7.00
Bio-control agents	11	75	14	13	72	15	13	79	8	17	71	12	18	70	12	14.40	73.40	12.20
Organic source	7	71	22	7	83	10	2	87	11	5	79	16	3	83	14	4.80	80.60	14.60
Seed treatment with fungicides	7	67	26	3	96	1	2	92	6	14	77	9	6	77	17	6.40	81.80	11.80
Seed treatment with bio-pesticides	8	85	7	2	98		5	90	5	4	77	19	5	82	13	4.80	86.40	8.80
Irrigation-Frequency	30	30	40	30	67	3	37	38	25	33	55	12	32	51	17	32.40	48.20	19.40
Irrigation-Quantity	1	88	11	29	68	3	17	43	40	3	92	5	3	92	5	10.60	76.60	12.80

Note: *C=Complete adoption; P=Partial adoption; N=Non-adoption

Table 3. Adoption status of improved livestock management practices for cattle and buffalo in all the dry zones of Karnataka

(Per cent)

Technology	Cattle			Buffalo		
	C*	P*	N*	C	P	N
High-yielding milch breeds	31.85	22.58	45.56	13.70	24.66	61.64
Artificial insemination	33.06	14.92	52.02	20.55	28.77	50.68
Feeding management	81.45	6.85	11.69	76.71	6.85	16.44
Housing management	80.65	6.85	12.50	64.38	17.81	17.81
Vaccination	60.08	19.76	20.16	68.49	15.07	16.44
Disease control measures	54.84	18.15	27.02	58.90	17.81	23.29
Credit/Loan/Subsidy schemes	3.63	9.68	86.69	10.96	4.11	84.93
Milk, milk products, preparation & their marketing	27.42	9.27	63.31	35.62	17.81	46.58
Insurance scheme	4.03	6.45	68.95	2.74	1.37	95.89
Record keeping	4.44	5.24	90.32	0.00	5.48	94.52
Value addition to livestock wastes	6.85	6.45	86.69	8.22	1.37	90.41
Meat and meat product preparation, marketing	0.40	0.00	99.60	0.00	1.37	98.63

Note: *C=Complete adoption; P=Partial adoption; N=Non-adoption

Table 4. Adoption status of improved livestock management practices for sheep, goat, poultry and sericulture in all the dry zones of Karnataka

(Per cent)

Technology	Sheep			Goat			Poultry			Sericulture		
	C*	P*	N*	C	P	N	C	P	N	C	P	N
Improved breeds/varieties	36.2	38.3	25.5	34.6	26.9	38.5	33.3	23.8	42.9	100.0	0.0	0.0
Housing management	61.7	21.3	17.0	65.4	26.9	7.7	76.2	9.5	14.3	100.0	0.0	0.0
Feeding management	72.3	17.0	10.6	80.8	3.9	15.4	52.4	19.1	28.6	80.0	20.0	0.0
Vaccination	51.1	25.5	23.4	46.2	30.8	23.1	33.3	38.1	28.6	-	-	-
Disease control	53.2	17.0	29.8	61.5	11.5	26.9	66.7	23.8	9.5	-	-	-
Wool/Egg/Silk reeling technology (grading/ processing/marketing)	4.3	12.8	83.0	3.9	19.2	76.9	47.6	4.8	47.6	80.0	0.0	20.0
Meat technology & processing	6.4	19.2	74.5	38.5	0.0	61.5	23.8	14.3	61.9	-	-	-

Note: *C=Complete adoption; P=Partial adoption; N=Non-adoption

Improved Livestock Management Practices in Sheep, Goat and Poultry and Silk Worm Rearing

Table 4 presents the adoption status of improved livestock management practices in sheep, goat, poultry and silk worm rearing in all the dry zones of Karnataka. Among the various technologies available for sheep rearing, complete adoption was highest in feeding management technology (72%) followed by housing management (62%) and disease control (53%). Verma *et al.* (2012) have reported that majority of sheep farmers showed higher adoption in case of improved feeding technologies, followed by breeds and breeding management. In Zone-5 and Zone-6, the complete adoption was recorded in breeding management and housing management technologies. The overall non-adoption status was found to be highest in wool technology (83%) which ranged from 50 per cent in Zone-3 to 100 per cent in Zone-6. Daniel (1999) has reported that 13.6 per cent large sheep farmers, 12.3 per cent medium and 11.1 per cent small sheep farmers adopted the improved sheep feeding technologies. The large sheep farmers had a higher adoption of scientific housing (21.0%) as compared to medium (14.2%) and small (13.2%) sheep farmers.

The adoption status of improved livestock management practices for goat indicated that, among all dry zones, respondents completely adopted feeding management technology (81%), followed by housing management (65%). Meena *et al.* (2011) have reported that farmers had a higher adoption about clean milk production, followed by management, feeding, breeds and breeding practices. The majority of goat farmers were partial adopters of feeding management practices (Kumar and Singh, 2015). Among different zones, Zone-2 recorded 100 per cent adoption in feeding management, vaccination and disease control technologies. Lahoti and Chole (2010) reported that the majority of goat farmers did not provide extra ration to the pregnant goats as per the requirement and they had low level of adoption of improved feeding practices.

On the other hand, the adoption status of improved livestock management practices for poultry indicated that housing management was adopted completely by the respondents across all the zones with highest adoption level (76.19%), followed by disease control (66.67%) and feeding management (52.38%). Khandait *et al.* (2011) have reported that poultry farmers highly adopted feeding and watering technologies (59.17%), followed by housing management technology (49.70%) and breeds and breeding technology (43.48%). The complete adoption of housing management recorded a wide variation ranging from zero per cent in Zone-2 to 87.5 per cent in Zone-3. However, in the case of non-adoption by respondents in all zones, breeds and breeding management practices recorded the highest (42.86%), followed by meat technology and processing (61.90%), feeding management and vaccination (28.57%). It was interesting to note that none of the respondents adopted breeds and breeding management practices in Zone-4.

For sericulture, particularly silk worm rearing, many technologies are practised in all the dry zones, except Zone-2 and Zone-3. Among various improved technologies, the overall 100 per cent complete adoption was found in silk worm rearing-improved varieties, mulberry cultivation-improved cultivars/ practices and housing management. Priyadarshini and Vijayakumari (2013) have reported that knowledge on mulberry cultivation practices was high, especially on variety (100%) and spacing (100%), the adoption level was also high with 60 per cent and 40 per cent, respectively. In the case of feeding management and silk reeling, 80 per cent complete adoption was recorded. The results also indicated that there was complete adoption of all the technologies in Zone-4. Kumaresan *et al.* (2005) have reported that improved practices such as high-yielding mulberry varieties, application of manures and chemical fertilizers, harvesting of mulberry leaf, disinfection of rearing house, maintenance of hygienic practices, maintenance of bed spacing, bed cleaning, mounting, harvesting of cocoons and control of uzifly in silkworm-rearing were adopted but not as per the recommendations, by the majority of the farmers. The separate rearing house, rearing of crossbred silkworm, incubation, black boxing, shoot rearing, maintenance of temperature and humidity in silkworm-rearing and control of mulberry pests and diseases were not practised by most of the surveyed farmers.

Adoption Status of Alternate Land Use Systems

Table 5 shows the adoption status of alternate land use systems. It indicates that across all the zones, only agriculture system was adopted by the majority of sample farmers (42.8%), followed by Agri-Horti system (20.0%) and integrated farming system (18.8%). The range of exclusive agriculture system's adoption varied with a lowest of 10 per cent in Zone-4 to a highest of 92 per cent in Zone-2. It could be observed from Table 5 that adoption of agri-horti system as well as fruit crop based horti system was nil in Zone-2. However, only 1.0 per cent of the respondents adopted integrated farming system in Zone-2 and Zone-3.

Adoption Status of Energy Management System

The adoption status of energy management system by the respondents is presented in Table 6, which revealed that, among different systems, bullock-drawn equipment for sowing topped in complete adoption

Table 5. Adoption status of alternate land use system

(Per cent)

Alternate land use system	Zone-2	Zone-3	Zone-4	Zone-5	Zone-6	Overall
Agriculture	92	70	10	12	30	42.80
Agri-horti system	0	18	28	25	29	20.00
Forestry-based cropping system	7	7	12	27	24	15.40
Fruit crop based horti-system	0	4	2	4	5	3.00
Integrated farming system	1	1	48	32	12	18.80

Table 6. Adoption status of energy management system

(Per cent)

Technology	Zone-2			Zone-3			Zone-4			Zone-5			Zone-6			Overall		
	C*	P*	N*	C	P	N	C	P	N	C	P	N	C	P	N	C	P	N
Tractor-drawn deep tillage equipment	82	18	0	63	15	22	71	5	24	68	9	23	66	13	21	70.0	12.0	18.0
Bullock-drawn equipment for sowing	73	23	4	68	20	12	89	3	8	85	7	8	72	18	10	77.4	14.2	8.4
Tractor-mounted reapers for harvesting	21	12	67	23	5	72	6	2	92	7	17	76	16	26	58	14.6	12.4	73.0
Improved hand tools	57	14	29	47	13	40	34	14	52	44	16	40	34	8	58	43.2	13.0	43.8
Improved sickles	64	9	27	44	15	41	39	17	44	43	17	40	23	11	66	42.6	13.8	43.6

Note: *C=Complete adoption; P=Partial adoption; N=Non-adoption

(77.4%), followed by tractor-drawn deep tillage equipment (70.0%) and improved hand tools (43.2%) across all the zones. Dipankar *et al.* (2001) have reported that a total of 188 rainfed farms had adopted a combination of bullock and tractor power (mixed farming), constituting 67.6% of the farms surveyed. It could be seen that the bullock-drawn equipment for sowing possesses a range varying from 68 per cent in Zone-3 to as high as 89 per cent in Zone-4. However, in the case of non-adoption, tractor mounted reapers for harvesting held the first position with 73 per cent, followed by improved hand tools and improved sickles (correspondingly 43.8% and 43.6%) across all the zones. It was noticed that non-adoption of tractor mounted deep tillage equipment was nil in Zone-2, whereas it was either adopted completely or partially by the respondent farmers of other zones. As a result of introduction of tractors, engines and electric motors, use of draught animals has reduced, but still they are used by some of the farmers (Kaumbutho *et al.*, 2000).

Jain *et al.* (2009) has examined the relation between adoption index and status of the infrastructure. The strong correlation between adoption index and composite index of infrastructure and development has emphasized the need for improving infrastructure to increase adoption of improved agricultural technologies, which would increase the value of per ha crop productivity.

Technology Adoption Indices

The Technology Adoption Index (TAI) for each farm household was worked out as per Kiresur *et al.* (2001) to understand the status of adoption of improved technologies, namely, Improved Soil and Water Conservation Technologies (ISWCT), Improved Crop Production Technologies (ICPT), Improved Livestock Management Practices (ILMP), Improved (Alternate) Land Use Systems (ILUS) and Improved Energy Management Systems (IEMS). The total technology components in each of these technology groups which were suitable for adoption in the specific study area were listed. The total number of such technology components formed the 'Technology Domain' or the denominator, while the number of technology components adopted by the farm household constituted the 'number of technologies completely adopted', and the ratio of latter to former multiplied by 100 constituted the TAI.

In Zone-2, the TAI ranged from 38 to 67 per cent in respect of complete adoption of ILMP (Table 7), while that of IEMS was 59 per cent and of ICPT was 23 to 46 per cent. The TAI values of ISWCT and ILUS were least (12 – 30% and 3%, respectively). On the other hand, in Zone-3, in terms of complete adoption, the highest TAI (68.14%) was in the case of Soil Health and Nutrient Management, a component under ICPT, while the least was in Plant Protection and Irrigation (24%). The next in order were the TAI for IEMS (49%), ILMP (26 - 48%), ISWCT (6 - 25%) and ILUS (6%). Contrarily in Zone-4, the TAI in terms of complete adoption was highest (100%) in sericulture, a component under ILMP, while the minimum was in cattle (38.15%). In IEMS, ICPT, ISWCT and ILUS, the TAIs of complete adoption were 48 per cent, 23 - 47 per cent, 11 - 29 per cent and 14 per cent, respectively. Similarly, the TAI of complete adoption in Zone-5 was highest (100%) in the case of sericulture under ILMP, while the least was in the case of cattle (34%), followed by 49.40 per cent in IEMS, 21 - 50 per cent in ICPT, 15 - 28 per cent in ISWCT and 15 per cent in ILUS. Zone-6 was not an exception. The technology adoption status, by and large, similar as in the case of other Zones, with 34 - 60 per cent of TAI (complete adoption) in ILMP, followed by 22 - 50 per cent in ICPT, 42 per cent in IEMS, 16 - 31 per cent in ISWCT and 12.75 per cent in ILUS.

Thus, across all the selected dry zones, the TAI was in general higher in the ILMP, followed by ICPT, IEMS and ISWCT, while the least was in ILUS. While there is an urgent need to enhance the status of technology adoption in ILMP and ICPT to still newer heights, the lower TAI in ILUS is of great concern. Alternative land use systems in each zone are to be analysed for their economic and environmental impact and the optimum one needs to be identified and adopted. In this regard, research and development strategies are to be re-oriented and strengthened.

Factors Affecting Adoption of Improved Farm Technologies

Several factors influence adoption of improved farm technologies. To identify these factors, multiple linear regression models were run with Technology Adoption Index (TAI) as the dependent variable and eleven independent variables, namely, age of respondent farmer (AGE), education (EDN), caste (CST), family size (FAM), social participation index (SOCPRT), size of landholding (LAND), proportion of irrigated land (IRRIG), diversification index (DVGNIND), non-crop income (NCINC), outstanding loan amount (LOANOUT) and impact indicator (IMPIND). Three such models, one each for adoption of Improved Soil and Water Conservation Technologies (ISWCT), Improve Crop Production Technologies (ICPT) and Improved Livestock Management Practices (ILMP), were estimated and the results are presented in Tables 8 through 10.

By and large, the R^2 values were very low for regression models for ISWCT and ICPT and higher for ILMP (59.4% for Zone-3 to 89% for Zone-2).

The regression analysis with respect to ISWCT revealed that in Zone-2, SOCPRT, IRRIG and DVFNIND influenced the technology adoption positively and significantly, of course, at different degrees of probability levels (Table 8), while in Zone-3, LAND, IRRIG and IMPIND were the major players which determined the technology adoption levels. Similarly, in Zone-4, LAND and IRRIG positively and significantly influenced the technology adoption process, while surprisingly the DVFNIND negatively affected the adoption. Contrastingly, in Zone-5, it was AGE and LOANOUT that positively but significantly influenced the technology adoption, whereas FAM negatively affected the same. Finally, in Zone-6, both IRRIG and IMPIND could influence the technology adoption significantly in a positive manner. Thus, in general, IRRIG, DVFNIND and LAND were the major factors affecting ISWCT adoption in the study area.

Interestingly, in respect of adoption of Improved Crop Production Technologies (ICPT), there were not many variables found significantly influencing the technology adoption (Table 9). There was not even one single variable significantly influencing ICPT adoption in both Zone-2 and Zone-5. However, in Zone-3, SOCPRT and IRRIG positively and significantly

Table 7. Technology adoption Indices for all the dry zones of Karnataka

Technologies / Technology components	Zone-2			Zone-3			Zone-4			Zone-5			Zone-6		
	C*	P*	N*	C	P	N	C	P	N	C	P	N	C	P	N
Improved soil and water conservation technologies															
Terrace level practices	29.86	4.00	66.14	25.00	6.57	68.43	29.14	3.86	67.00	28.43	12.14	59.43	30.86	9.57	59.57
Inter terrace level practices	19.78	4.89	75.33	22.00	7.22	70.78	26.89	5.67	67.44	27.34	11.22	61.44	26.78	8.00	65.22
Water harvesting structures	12.67	3.50	83.83	5.50	1.67	92.83	11.33	1.00	87.67	15.33	9.50	75.17	16.33	7.00	76.67
Water surplussing and grade estabilisation structures	16.50	5.33	78.17	16.50	1.50	82.00	12.00	3.25	84.75	19.17	9.67	71.17	19.67	6.33	74.00
Improved crop production technologies															
Crop management practices	46.20	43.33	10.47	50.67	12.40	36.93	32.87	53.40	13.73	34.67	50.07	15.26	36.33	50.20	13.47
Soil health & nutrient management	44.57	41.72	13.71	68.14	8.00	23.86	47.43	20.00	32.57	50.29	39.85	9.86	49.57	43.14	7.29
Plant Protection & Irrigation	23.00	59.57	17.43	24.00	5.14	70.86	23.14	61.57	15.29	21.28	66.86	11.86	21.86	66.00	12.14
Improved livestock management practices															
Cattle	53.33	15.22	31.45	33.56	8.77	57.67	38.15	11.48	50.37	34.08	13.34	52.58	34.00	15.00	51.00
Buffalo	43.88	32.87	23.25	40.89	10.67	48.44	51.00	13.56	35.44	37.63	17.00	45.37	37.37	33.25	29.38
Sheep	38.29	23.14	38.57	26.29	17.86	55.85	57.00	33.80	9.20	54.43	19.00	26.57	35.00	27.86	37.14
Goat	66.60	33.40	0.00	38.00	12.71	49.29	60.00	35.00	5.00	57.00	18.80	24.20	35.43	50.00	14.57
Poultry	50.00	10.00	40.00	48.29	17.86	33.85	44.00	40.00	16.00	64.86	16.57	18.57	-	-	-
Sericulture	-	-	-	-	-	-	100.00	0.00	0.00	100.00	0.00	0.00	60.00	20.00	20.00
Alternate land use system	3.00	2.00	95.00	6.00	1.50	92.50	14.00	4.50	81.50	15.00	7.00	78.00	12.75	8.00	79.25
Energy management system	59.40	15.20	25.40	49.00	13.60	37.40	47.80	8.20	44.00	49.40	13.20	37.40	42.20	15.20	42.60

*C=Complete Adoption; P=Partial Adoption; N=Non-Adoption.

Table 8. Factors determining adoption of improved soil and water conservation technologies (ISWCT)

Variables	Zone-2	Zone-3	Zone-4	Zone-5	Zone-6
Constant	19.6160***	9.3400	18.4300***	19.6890***	19.2480***
AGE	-0.0130	0.0190	0.0250	0.1780**	-0.0220
EDN	0.0020	-0.1590	-0.0520	0.3390	-0.1070
CST	-0.8380	-1.0220	-1.0330	-0.2550	0.8760
FAM	-0.2560	0.2750	0.0790	-0.7170*	0.1040
SOCPRT	4.8760**	-0.5630	3.0970	-7.6490	0.6810
LAND	-0.0390	0.3700***	0.3610**	0.4290	-0.2530
IRRIG	0.0270*	0.0690***	0.0970***	-0.0120	0.0380**
DVFNIND	0.2750***	0.0840	-0.2410***	0.0180	-0.1770
NCINC	0.0000	-0.0001	0.0000	0.0000	0.0001
LOANOUT	0.0000	0.0000	0.0000	0.0000*	0.0000
IMPIND	-0.2050	0.2860*	0.0530	-0.1420	0.2460**
R^2	26.4	33.8	35.1	19.5	17.4
F	2.871***	4.092***	4.325***	1.940**	1.690*

Table 9. Factors determining adoption of improved crop production technologies (ICPT)

Variables	Zone-2	Zone-3	Zone-4	Zone-5	Zone-6
Constant	36.4470***	42.9350***	33.3200***	38.0140***	29.1460***
AGE	-0.0180	0.0210	-0.0600	-0.0120	-0.0080
EDN	-0.0490	0.3090	0.1130	-0.0320	-0.0520
CST	-0.1730	0.6220	0.4290	-0.1470	1.1230
FAM	0.2930	-0.0320	-0.1700	-0.3970	0.3900
SOCPRT	-1.4160	5.3380*	0.4130	-0.9280	-1.7210
LAND	0.1970	-0.1090	-0.0380	0.1880	-0.5030
IRRIG	0.0260	0.0560**	0.0550**	0.0120	0.0630***
DVFNIND	-0.0860	-0.0070	-0.0220	0.0390	-0.1090
NCINC	0.0000	0.0000	0.0000	0.0000	0.0001
LOANOUT	0.0000	0.0000	0.0000	0.0000	0.0000*
IMPIND	0.1880	-0.2310	0.0240	-0.0130	-0.0420
R^2	13.0	18.4	12.7	5.9	20.8
F	1.195	1.798*	1.166	0.499	2.102**

influenced ICPT adoption. Similarly in Zone-6, two variables, namely, IRRIG and LOANOUT were the major ones promoting technology adoption. But in Zone-4, the loan variable positively influencing ICPT adoption was IRRIG. Thus, across zones, it was only the IRRIG that positively contributed to ICPT adoption.

The regression models for ILMP were relatively good fit, as indicated by the R^2 values and F value (significant at 1% probability level) in the case of all the selected zones (Table 10). As many as five explanatory variables were found significantly influencing ILMP adoption in the selected area, viz., DVFNIND, LAND, CST, FAM and IMPIND. Similarly, in Zone-4, four variables determined ILMP adoption, namely, DVFNIND, NCINC, FAM and IMPIND; surprisingly, IMPIND had a negative influence on ILMP adoption. In Zone-3 and Zone-5, two factors, namely, LAND and DVFNIND, influenced ILMP adoption; however, LAND had a negative impact. In Zone-6, there was only one factor that

Table 10. Factors determining adoption of improved livestock management practices (ILMP)

Variables	Zone-2	Zone-3	Zone-4	Zone-5	Zone-6
Constant	-11.8090***	0.7120	-7.9880***	-4.6610	-7.0030***
AGE	0.0040	-0.0630	0.0180	-0.0100	0.0230
EDN	-0.0460	-0.2220	0.0010	0.0910	-0.0230
CST	0.4460*	-0.6150	0.2960	-0.2480	-0.1110
FAM	0.1410*	-0.1680	0.2770*	-0.1930	-0.0890
SOCPRT	-1.0960	-3.0550	-0.1500	-1.7980	0.8480
LAND	0.1370**	0.2140**	-0.0700	-0.4250**	0.0910
IRRIG	0.0100	-0.0060	0.0060	-0.0020	0.0030
DVFNIND	0.6620***	0.6100***	0.5170***	0.5980***	0.6240***
NCINC	0.0000	-0.0001	0.0000***	0.0000	0.0000
LOANOUT	0.0000	0.0000	0.0000	0.0000	0.0000
IMPIND	0.1140*	0.1190	-0.0610*	0.0370	-0.0190
R^2	89.0	59.4	83.6	65.7	77.0
F	65.007***	11.729***	40.634***	15.339***	26.843***

significantly affected ILMP adoption and that was DVFNIND, which did influence the ILMP adoption positively. The F values were highly significant in the case of all the zones and R^2 values were relatively much higher than that in the case of ICPT and ISWCT. Thus, across zones, DVFNIND was the most important factor that positively influenced the ILMP adoption, followed by LAND, FAM and IMPIND.

Impact of Selected Improved Dry Land Farming Technologies

Table 11 presents the impact of improved dryland technologies on resource-use efficiency, profitability, standard of living, women's participation and women's drudgery. Improved technologies, viz., crop management, livestock management, soil and water conservation and energy management technologies were practised in the study area to a varying extent. Across all dry zones and various technology components, the average improvement in resource-use efficiency was 21.37 per cent and it was found to be highest in Central Dry Zone (28.1%), followed by Eastern dry Zone (26.3%). In terms of increase in profitability, an average of 22.75 per cent was observed in all the zones; Central Dry Zone constituted the highest increase in profitability (38.51%), followed by North Eastern Dry Zone (20.07%). Sadaqath and Devendrappa (2011) have reported that by adoption of soil and water conservation practices like contour bunds (to the extent of 55.34%), water ways (44.0%), strengthening of existing bunds (42.7%) and ploughing across the slope (29.3%), the average production and productivity in *kharif* season increased by 25.0 per cent and 27.8 per cent, respectively. The results also showed that there was an improvement in the standard of living ranging from 11.4 per cent in Northern Dry Zone to 17.5 per cent in North Eastern Dry Zone with the overall average of 14.96 per cent across all the zones. Women's participation increased due to adoption of improved technology over the traditional technology by around 22.95 per cent in Eastern Dry Zone succeeded by North Eastern Dry Zone (13.59%), while least participation was recorded in Northern Dry Zone (6.25%). Table 11 also depicts that, on an average, there was about 8.19 per cent reduction in women's drudgery which was maximum in Eastern Dry Zone (12.1%) and minimum in Northern Dry Zone (3.49%). Ramarao *et al*. (2014) have reported that improved technology could increase the net returns of farmers by 20-84 per cent, depending upon their farm size categories in the study districts. In the absence of credit, the net returns declined up to 80 per cent.

Thus, it could be seen that a vast unexploited yield reservoir exists in different crop-mix production systems, and a major portion of this yield gap is Yield Gap-II (extension gap) as against Yield Gap-I (research gap). One may not be totally wrong if he/she suggests a total moratorium on research for a couple of research

Table 11. Impact of selected improved dryland technologies adopted by the sample farmers on resource-use efficiency, profitability, standard of living, women's participation and women's drudgery

Zone	Technology	Improvement in resource-use efficiency (%)	Increase in profitability (%)	Improvement in standard of living (%)	Increase in women's participation (%)	Reduction in women's drudgery (%)
Zone-2	Improved crop production technologies	13.94	20.02	17.60	13.22	9.73
	Improved livestock management practices	10.00	25.00	10.00	50.00	15.00
	Overall	13.90	20.07	17.52	13.59	9.78
Zone-3	Improved crop production technologies	16.47	13.81	11.36	6.30	3.51
	Improved livestock management practices	30.00	30.00	12.50	4.50	2.50
	Overall	16.85	14.26	11.39	6.25	3.49
Zone-4	Improved crop production technologies	27.68	35.49	15.42	12.23	8.45
	Improved livestock management practices	31.76	60.00	24.29	14.82	9.25
	Improved soil and water conservation technologies	27.12	33.94	13.15	11.85	8.00
	Overall	28.10	38.51	16.05	12.50	8.44
Zone-5	Improved crop production technologies	26.49	19.95	17.59	22.58	12.02
	Improved soil and water conservation technologies	10.00	10.00	5.00	60.00	20.00
	Overall	26.32	19.85	17.47	22.95	12.10
Zone-6	Improved crop production technologies	18.18	14.62	10.83	10.17	5.68
	Improved livestock management practices	35.00	12.50	7.50	3.50	3.00
	Improved soil and water conservation technologies	26.00	17.50	12.00	7.00	3.50
	Improved energy management practices	15.00	30.00	10.00	5.00	2.00
	Overall	18.68	14.80	10.77	9.90	5.53
All Zones		21.37	22.75	14.96	13.50	8.19

and a targeted effort on Yield Gap-II in order to plug the gaps in reaping the benefits of improved technologies under various agro-biological situations.

Conclusions

The study has found that across all the selected dry zones in Karnataka, the Technology Adoption Index (TAI) was in general highest in the ILMP, followed by ICPT, IEMS and ISWCT, while the least was in ILUS. While there is an urgent need to enhance the status of technology adoption in ILMP and ICPT to still newer heights, the lower TAI in ILUS is of great concern. Alternative land use systems in each zone are to be analysed for their economic and environmental impact and the optimum one needs to be identified and adopted. In this regard, research and development strategies are to be re-oriented and strengthened. The regression analysis with respect to ISWCT revealed that, in general across the selected dry zones, IRRIG, DVFNIND and LAND were the major factors affecting ISWCT adoption in the study area. Interestingly, in respect of ICPT, there were not many variables found significantly influencing the technology adoption. Across zones, it was only the IRRIG that positively contributed to ICPT adoption. The regression models for ILMP were relatively good fit as indicated by the R^2 values and F value (significant at 1% probability level) in all the selected zones. Across zones, DVFNIND was the most important factor that positively influenced the ILMP adoption, followed by LAND, FAM and IMPIND.

The potential impact due to the adoption of improved dryland technologies, across all dry zones, in terms of the average improvement in resource-use efficiency was 21.37 per cent, the average increase in profitability was 22.75 per cent, the average improvement in standard of living was 14.96 per cent, increase in women's participation was to the tune of 13.50 per cent and reduction in women's drudgery was to the extent of 8.19 per cent. Given the technology adoption levels much below the desired levels, the extension gap (Yield Gap-II) needs to be more focussed than research gap (Yield Gap-I) in the next 4-5 years. Further, in order to achieve the Central Government's resolve to "double farmers' income by 2022", a multi-pronged approach needs to be adopted by all concerned in a consistent and planned manner, since the contributions to double the farm incomes can come not only from technological innovations/inventions, but also significantly from institutional support, infrastructural facilitation and policy intervention.

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