Indian Research Journal of Extension Education
RESEARCH ARTICLE

Stakeholder Linkages Analysis in Integrated Farming System for Technology Reach in Select Agro-Climatic Zones of Karnataka

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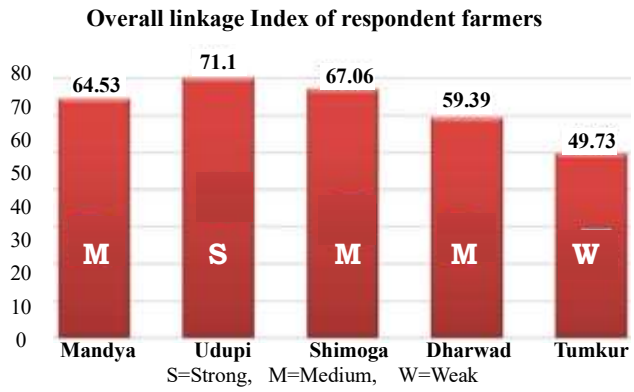
HIGHLIGHTS

- Socio-Economic factors influencing Stakeholder Linkage. The dynamics of key stakeholder linkages in IFS
- Actor Linkage Matrix. Roles & Actions performed by Stakeholders in IFS as perceived by farmers
- Comparative Linkage between IFS respondent farmers and other Stakeholders. Overall Linkage Index

GRAPHICAL ABSTRACT



ARTICLE INFO

Editor:
Dr. Satyapriya
Dr. Anirban Mukherjee

Key words:
Stakeholders, Integrated farming system, Key informant technique, Actor linkage matrix, Technology reach and Linkage index.

Received : 22.07.2024
Accepted : 28.08.2024
Online published : 01.10.2024

doi:10.54986/irjee/2024/oct_dec/73-83

IRJEE METRICS

ABSTRACT

Introduction: Stakeholder linkage studies in integrated farming systems (IFS) are crucial for understanding complex relationships in Indian agriculture.

Context: By identifying the strengths and weaknesses of stakeholder networks, the studies inform the development of targeted interventions, policies, and support mechanisms to enhance the adoption and success of IFS in India.

Objective: To dentify the stakeholders of IFS and extent of linkage for technology reach. The study envisages the active role of stakeholders in technology dissemination and diffusion in Karnataka State of India.

Method: An Actor Linkage Matrix was developed to study the extent of reciprocal linkage among the stakeholders of IFS in select five districts with 250 farmer respondents and 100 other stakeholders; further analyzed the roles & actions performed by stakeholders to help farmers in adopting the IFS

Results & Discussion: The research results indicated that, overall linkage index was strong in case of Udupi district from coastal zone (70.10), moderate in Shimoga district from Hilly zone (67.06), Mandya district from Southern dry zone (64.53), Dharwad district from Northern Transitional zone (59.39) districts and found to be weak in Tumkur district from central dry zone (49.73) district. The research investigated the various roles by stakeholders such as technology transfer, awareness creation, financial support, policy formulation, facilitation, research assistance, collaboration, and training in IFS. It explored the specific actions taken by stakeholders in disseminating information, human resource development and facilitating market access.

Significance: To bridge gaps in technology adoption, a unified platform for strong research-extension-farmer-market linkage is essential. This approach aims to disseminate advanced agricultural technologies in farmers' fields.

Increasing agricultural productivity especially food production has made India self-sufficient in food production during 1960's. But at household level food sufficiency and nutritional security remained a question, necessitating the need to work in farming system mode (Kaur *et al.,* 2021). Integrated farming systems (IFS) optimize resource use by integrating crops, vegetables, livestock, fishery, poultry, and agroforestry. When it comes to nutritional security, vegetables play a crucial role (Noopur *et al.,* 2023) in IFS. Integrated farming systems optimize resource use by combining crops, livestock, fishery, poultry, and agroforestry. However, the success of these systems depends on effective interactions and collaborations among stakeholders. These stakeholders include farmers, agricultural extension agencies, research institutions, input suppliers, financial institutions, market intermediaries, policymakers, consumers etc. Stakeholders are individuals or groups with a position or interest in an issue or activity, influencing or being influenced by innovations or changes in the social and agricultural systems. Primary stakeholders are those affected by interventions, either positively as intended beneficiaries or negatively. Secondary stakeholders are responsible organizations delivering services to primary stakeholders, having a major interest in resource management. Examples include NGOs, FPOs, SHGs, government departments, private companies, and religious institutions. Agricultural value chain stakeholders in IFS alleviate distress and bridge technology gaps by supporting farmers, enhancing linkages, and overcoming barriers, fostering sustainable development and improved livelihoods. (Ramya *et al.*2019). Stakeholder analysis entails examining the current patterns of connections, interests, goals, power dynamics, and relationships within a system. It centers on the actors, their agendas, the environments they engage in, and the partnerships they establish with other participants. (Zimmerman and Maennling, 2007). Understanding the system and stakeholders is crucial for facilitating change. The Four R framework (Rights, Responsibility, Revenue, Relationship) aids in stakeholder analysis (Mohammad *et al.* 2012), identifying network connections. In innovation systems, stakeholders play diverse roles (Leeuwis, 2004; Klerkx and Gilemacher, 2012), with the potential for the extension system to shift towards fostering innovation (Hall 2007; Davis and Heemskerk 2012; Rajalahti 2008). India's agricultural extension services are varied, encompassing multiple advisory channels. Hence agricultural information is vital for development & enhancing technology adoption. (Himeur, 2023) There is great scope for private extension service southern States like Kerala where there is huge cringe in manpower. (Veettil and Venkataranga Naika, 2019). Also Multimedia training modules enhance farmers' knowledge and aid in retaining the acquired information. (Sahu *et al.* 2022; Jha *et al.* 2021). Organizational capacity assessment tool is vital for FPOs, NGOs, private, and government entities as it allows stakeholders to self-assess, understand their current capacity and plan for the future. (Venkatta kumar *et al.* 2023)

In Karnataka State, the ratio of operational holdings per extension official is significantly high at 2428:1 depicting that one extension professional is addressing 2428 farmer's issues/problems in turn it highlights the need for an optimal blend of manpower and technology-based extension services. (Ramya *et al.* 2021) To bridge this gap, it is essential to create a common platform involving public, private, and NGO extension service providers to disseminate advanced agricultural technologies effectively. Strong cooperation and partnerships among stakeholders are crucial to address challenges along with avoiding duplication of efforts, and achieving cost-effective outcomes. Hence the objective of this research is to study stakeholder linkages among Integrated Farming Systems (IFS) in specific agro-climatic zones of Karnataka State.

METHODOLOGY

Selection of study area : The present study was conducted in the representative districts of selected five agro climatic zones of Karnataka (latitude 11°30′N and 18°30'and longitude 74°E and 78°30′E) State namely Northern Transitition zone - Dharwad, Central dry zone- Tumkur, Southern dry zone-Mandya, Hilly zone- Shimoga and Coastal zone-Udupi as integrated farming system is predominant practice in respective districts. A well-structured interview schedule was used as a tool for the data collection in research. The collected data was tabulated, and analyzed using descriptive statistics, Linkage Index and Actor Linkage Matrix (ALM).

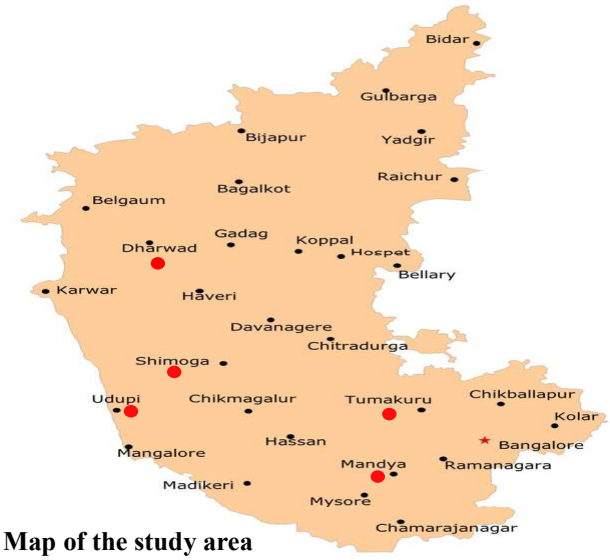
Linkage Index : Linkage index developed by Devi (2004) was used to measure the extent of linkage

between selected stakeholders under Research – Extension-Farmer linkage. The frequency of linkage activities was ascertained on a three-point continuum as more frequently, frequently and occasionally with the scores 3, 2 and 1 respectively. Extent of linkage was measured based on the scores obtained against frequency of activities. Linkage index was calculated by using the formula as mentioned below.

$$\text{Linkage index} = \frac{\text{Actual score x obtain}}{\text{Max. possible score}} \times 100$$

Formation of Actor Linkage Matrix: The Actor Linkage Matrix (ALM) is a tool used to analyse stakeholder interactions, map linkages, and understand the flow of information among actors. It helps identify key institutional linkages for effective innovation systems. (Muhammad, 2007 and Smitha, 2019). ALM provides insights into interaction patterns, aiding in identifying robust linkages for goal achievement (Gupta, 2017; Suchiradipta and Raj, 2014). In order to assess the information flow within the agricultural system, actors were surveyed to identify the other actors they relied on for information. The matrix summarized the strength of the linkages between actors, including the direction of information movement. The strength of linkage is expressed as strong (S) when linkage index value is >70, medium (M): 50 to 69 and weak (W): <50.

Selection of stakeholders: To identify different stakeholder's key informant technique and Focus group discussion was used. The study covers research sample distribution over five districts and ten blocks with 50 respondents in each district. The total sample size for the research is 350, encompassing



Map of the study area

Table 1. Socio-economic factors influencing Stakeholder Linkage (N=250)

SE Factors/category	No.	%	ALI (%)
Age (years)			
Young (<35)	61	24.4	71***
Middle (35-55)	136	54.4	56**
Old (>55)	53	21.2	43*
Family size			
Small (Upto 5)	93	37.2	52**
Medium (6-7)	114	45.6	66**
Large (> 8)	43	17.2	78***
Land holding			
Marginal (<2.5 acres)	70	28.4	48*
Small (2.5 – 5 acres)	135	54	54**
Large farmer (>5 acre)	45	17.6	80***
Animal holding			
Small (5 Animals)	85	34	47*
Medium (6-10 Animals)	119	47.6	58**
Large (11 & Above)	46	18.4	78***
Risk orientation			
Low	62	24.8	43*
Medium	127	50.8	56**
High	61	24.4	73***
Innovativeness			
Low	60	24	40*
Medium	127	50.8	52**
High	63	25.2	82***

ALI=Av. linkage index;
Linkage category = *Weak; **Medium; ***Strong

250 respondents and an additional 100 stakeholders involved in different domains, such as SDA & SDH, AHD, SAU, KVAFSU, KVK & RSK, Commodity boards, Private Companies/Input agencies, Farmer Cooperative/KMF, and FPO's/CIG/SHGs.

RESULTS

Socio-Economic factors influencing Stakeholder Linkage: The results from Table 1 depicts that 24.40% of farmers from study sample belonged to young farmer category and they had strong linkage (71%), Older farmers resist new interventions, resulting in weaker linkages (43%), while middle-aged farmers show moderate linkage (66%). Large family-sized farmers exhibit robust linkages (80%) due to increased community connections. Those with larger land and animal holdings demonstrate strong linkages (80% and 78%), indicating a positive correlation. Farmers with higher risk orientation and innovativeness (73% and 82%) establish effective connections, contributing

Table 2. Actor Linkage Matrix among the key stakeholders of Integrated Farming System

Stakeholders	Farmers	SDA & SDH	AHD	SAU	KVAFSU	KVK	Commodity boards / APMC	Private / Input agencies	Farmer	FPO's / CIG/SHG
Farmers		M (68.3)	W (48.1)	M (67.7)	W (40.6)	S (94.2)	M (62.6)	W (40.4)	S (86.5)	M (60.5)
SDA & SDH	M (64.6)		S (88.6)	S (84.3)	S (75.2)	S (90.1)	M (68.8)	W (38.2)	M (66.0)	M (59.3)
AHD	M (61.4)	M (66.0)		M (65.7)	S (92.3)	W (49.7)	W (47.1)	W (35.6)	S (78.2)	M (55.8)
SAU	M (68.9)	S (87.5)	M (61.2)		M (64.6)	S (75.5)	W (33.3)	W (30.0)	W (37.8)	M (54.7)
KVAFSU	M (55.6)	M (63.3)	S (93.3)	S (78.8)		M (56.3)	W (27.8)	W (25.0)	S (73.6)	M (55.0)
KVK/RSK	S (90.3)	S (94.6)	M (60.0)	S (86.3)	M (62.5)		M (69.0)	W (40.4)	W (42.5)	M (61.5)
Commodity boards / APMC	S (76.5)	S (81.2)	W (41.6)	W (25.0)	W (34.7)	M (52.5)		W (45.6)	W (48.3)	S (72.8)
Private Companies /Input agencies	S (71.3)	W (41.4)	W (49.1)	W (20.0)	W (32.5)	W (27.0)	M (55.6)		M (65.7)	S (74.5)
Farmer Cooperatives/ KMF	S (85.3)	M (60.7)	S (88.2)	W (37.3)	S (76.2)	W (45.0)	W (44.2)	S (77.5)		M (65.6)
FPO's / CIG/ SHGs	S (74.9)	S (80.0)	M (57.4)	M (51.3)	W (37.5)	S (73.7)	S (80.2)	M (66.0)	M (58.5)	

*Categories: S- Strong: >70, M- Medium: 50 to 69, W- Weak: <50 Linkage Index Value (LIV)

*SDA: State Department of Agriculture, SDH: State Department of Horticulture, AHD: Animal husbandry department, SAU: State Agriculture Universities, KVAFSU: Karnataka Veterinary and Fishery Science University, KVK: Krishi Vigyan Kendra, RSK: Raitha Samparka Kendra, APMC: Agriculture Produce Marketing Committee, KMF: Karnataka Milk Federation, FPOs: Farmer Producer organization, CIG: Commodity interest groups, SHGs: Self help groups

to more profitable ventures and vice versa. The results are in line with the similar study by Basera & Bhardwaj (2022) and Shyam Suraj & Kadian (2022).

The dynamics of key stakeholder linkages in Integrated Farming System : The role of stakeholders involved in technology transfer, their interaction pattern, their level of connectedness was studied using linkage index through actor linkage matrix depicted through Table 2.

*Actor Linkage Matrix: I*nteraction among the stakeholders is presented using actor linkage matrix where selected actors are listed in both the row and column of the matrix and their relation and interaction is described in the intersection cells as indicated in Table 2. It was evident that some of the actors played very crucial role whereas, some other were having very little contribution in the information flow and technology transfer. The results from the Table 2 indicate that the farmers in the study demonstrated strong reciprocal linkages with key stakeholders such as Krishi Vigyan Kendras (LIV=94.20) & Farmers (LIV=90.30), whereas linkage between Farmers & Milk Cooperatives like KMF was LIV=86.50, Cooperatives & Farmers (LIV=85.30).

FPO's involved in marketing agricultural products and dairy feed supplements also had strong linkages with farmers, SDA & SDH, KVK and commodity boards with LIV=74.90, 80.00, 73.70 & 80.20 respectively. Similarly, KVKs and SAUs, KVAFSU & SAUs maintained strong reciprocal linkages (LIV=86.30) & LIV=78.80) respectively as they played a vital role in disseminating benefits to farmers in the agricultural sector. On the other hand, private/input agencies had strong linkage with farmers and FPO's (LIV=71.30) & 74.50) & weak connections between other stakeholders like SDA & SDH (41.40), AHD (49.1), SAU (20.00), KVAFSU (32.50) & KVK (27.00). whereas Private and public sector linkages were weak which requires strengthening. There is a medium

Table 3. Roles performed by Stakeholders in IFS perceived by farmers (N = 250)

Stakeholders/ Roles	No.	%
Farmers		
Receiver of technology	250	100
Awareness	226	90.4
Transfer of technology	25	10
SDA & SDH		
Finance support	230	92
Policy formulation and implementer	156	62.4
Facilitator	70	28
Coordinator	140	56
Research	132	52.8
AHD		
Policy formulation and implementer	175	70
Research	100	40
Transfer of Technology	120	48
Collaborator	85	34
Finance support	228	91.2
SAUs		
Education	190	76
Awareness	165	66
Transfer of Technology	150	60
Policy implementation	230	92
Research	80	32
KVAFSU		
Education	170	68
Awareness	185	74
Transfer of Technology	140	56
Policy implementation	73	29.2
Research	90	36
KVK/RSK		
Training and Demonstrations	240	96
Awareness	160	64
Transfer of Technology	200	80
Policy implementation	182	72.8
Research	195	78
Facilitator	130	52
Commodity boards/APMC		
Marketing	210	84
Finance support	180	72
Awareness	196	78.4
Farmer Cooperatives/KMF		
Marketing	250	100
Awareness	120	48
Value addition & processing	176	70.4
Finance support	211	84.4
Collaborator	152	60.8
FPO's / CIG/ SHGs		
Marketing	240	96
Collaborator/Aggregator	200	80
Awareness	56	22.4
Receiver of technology	91	36.4
Transfer of technology	60	24
Private /Input agencies		
Marketing	233	93.2
Collaborator/Aggregator	123	49.2
Brokerage	68	27.2

level linkage between SDA (68.30), AHD (64.60), SAU (68.90) and farmers while there is weak linkage between commodity boards with these stakeholders. Medium linkages existed between KMF, the State Department of Agriculture/Horticulture (66.00) and FPOs/CIGs/SHGs (58.50). In Udupi district, farmers formed strong linkages with opinion leaders, KVK, State Department of Agriculture, SHIMUL (Milk Cooperatives), commodity boards, APMC markets and farmer organizations. Similarly, Shimoga and Mandya districts farmers demonstrated strong relationships with fellow farmers, SDA, KMF, farmer union and KVK. In Dharwad, reliance on extension staff, SAU experts, veterinary services, and DAMUL created robust linkages. Severe drought weakened connections in Tumkur, impacting agriculture negatively.

Roles performed by Stakeholders in Integrated Farming System as perceived by farmers : Table 3 summarizes key roles of stakeholders in Integrated Farming Systems (IFS). Notably, the "farmer friend," acknowledged as a progressive farmer and vital informant, is deemed essential by 100% of respondents for technology transfer and information dissemination. The findings indicate that 92.00% of respondent farmers recognize the State Department of Agriculture and Horticulture as the lead stakeholder providing financial support and driving policy formulation. Additionally, 62.40% of respondents acknowledge the SDA & SDH for their diverse roles, encompassing policy formulation, technology dissemination, awareness creation, facilitation, technology transfer etc. The KVK, recognized by 96.00% of farmers, plays a vital role in research-extension linkages and on-farm trials, dissemination of IFS technologies. Raitha Samparka Kendras (RSKs) at the Hobli level, acknowledged by 50.00% of respondents, act as intermediaries with the State Agriculture Department. State Agricultural Universities (SAUs) contribute significantly, with 76.00% acknowledging educational videos and 66.00% continuous reporting for IFS awareness. KVAFSU, focused on education and research, has a limited role, with 36.00% awareness among farmers. Karnataka Milk Federation (KMF) is highly valued for substantial financial support by 84.40% of farmers, particularly in the dairy sector. Commodity boards, APMC, and FPOs/CIG/SHGs are recognized for marketing support, awareness creation etc. Some farmers (27.20%) acknowledge Private agencies for marketing services (93.20%), with brokerage based on

Table 4. Actions performed by Stakeholders as perceived by respondent farmers

Stakeholders/Actions	No.	%
Farmers		
Dissemination of information	168	67.2
Convening	182	72.8
Brokerage	60	24.0
SDA & SDH		
Dissemination of information	176	70.4
Advocating	88	35.2
Human resource development	157	62.8
AHD		
Dissemination of information	195	78.0
Convening	166	66.4
SAUs		
Coaching	210	84.0
Convening	174	69.6
Human resource development	206	82.4
Advocating	139	55.6
KVAFSU		
Coaching	200	80.0
Convening	184	73.6
Human resource development	180	72.0
Advocating	164	65.6
KVK		
Dissemination of information	240	96.0
Human resource development	200	80.0
Advocating	217	86.8
Commodity boards /APMC		
Dissemination of information	130	52.0
Convening	96	38.4
Brokerage	67	26.8
Farmer cooperatives/ KMF		
Convening	190	76.0
Dissemination of information	221	88.4
Coaching	75	30.0
FPO's / CIG/ SHGs		
Dissemination of information	100	40.0
Coaching	115	46.0
Convening	240	96.0
Private /Input agencies		
Mediating	170	68.0
Brokerage	135	54.0
Dissemination of information	80	32.0

commodity and area.

Actions performed by Stakeholders perceived by respondent farmers: Stakeholder actions in Karnataka State, illustrated in Table 4, reveal that the majority (70.40%) believe that SDA, SDH & ADH effectively disseminate information and ensure proper use of allocated funds through monitoring and evaluation. They also contribute to human resource development (62.80%) and advocate policy changes and innovation in extension and adoption (35.20%). SAU's & KVAFSU focus on agricultural education (84.00% & 80.00%, respectively) and capacity-building (82.40% & 72.00%). ICAR-KVK / State-funded KVK and RSK disseminate IFS information (96.00%), while progressive farmers act as para extension agents (67.20%) and brokers (24.00%). Commodity boards/ APMC, Farmer Cooperatives/KMF, FPO's/CIG/SHGs, and Private Companies/Input agencies contribute significantly to commodity trading, and marketing.

Comparative Linkage between IFS respondent farmers and other Stakeholders

Stakeholders' linkage among IFS farmers of Mandya district (Southern dry Zone): The results of Table 5 shows that in Mandya district, farmers exhibit strong linkage index with farmer friends (78.67), KVK (77.33), MANMUL milk cooperatives (76.67), and farmer organizations/unions (74.67). They maintain a medium-level linkage with SAUs (66.00), commodity boards (62.67), State Dept of Agriculture and Horticulture (57.33), and private companies/ input agencies (54.67). However, weaker linkages are observed with State Dept. of Animal Husbandry (49.33) and KVAFSU (48.00).

Stakeholders' linkage among IFS farmers of Udupi district (Coastal zone) : From the Table 5, it is inferred that the IFS farmers in Udupi district demonstrate robust linkages, notably with farmer friends (83.33), KVK (81.33), Milk cooperatives (80.00), and Farmer unions/clubs (79.33). State Dept. of Agriculture and Horticulture maintains a strong linkage (76.00), while commodity boards (75.33), SAU (67.33), and State Dept. of AHD (64.67) exhibit medium linkages. Conversely, private Companies/Input agencies (48.67) and KVAFSU (44.67) show weaker linkages.

Stakeholders' linkage among IFS farmers of Shimoga (Hilly Zone) : Table 5 indicate strong linkages of IFS farmers in Shimoga district with farmer friends (84.67), KMF-SHIMUL (Milk cooperatives) (78.67),

Table 5. Comparative Linkage Index between IFS Respondent farmers and other Stakeholders

Linkage of Farmers	Mandya	Udupi	Shimoga	Dharwad	Tumkur
Farmers	79***	83***	85***	68**	63**
SDA & SDH	57**	76***	72***	46*	51**
AHD	49*	65**	61**	47*	44*
SAU	66**	67**	63**	71***	43*
KVAFSU	48*	45*	55**	44*	41*
KVK	77***	81***	65**	63**	62**
Commodity boards /APMC	63**	75***	67**	49*	46*
Farmer Cooperatives/KMF	77***	82***	79***	80***	51**
Self Help Group / FPOs/CIGs	82***	72***	49*	69**	45*
Private/Input Companies	55**	49*	77***	57**	53**

*Categories: ***Strong: >70, **Medium: 50 to 69, *Weak: <50 Linkage Index Value (LIV)

farmer unions/clubs/CIGS/Producer companies (77.33), and the State Department of Agriculture and Horticulture (72.00). Commodity boards (Arecanut, cashew, coconut, coffee, rubber) (66.67), KVK (65.33), SAU (62.67), and the State Department of Animal Husbandry (60.67) exhibit medium level of linkage. Private/Input agencies show weaker connections (47.33) with IFS farmers.

Stakeholders' linkage among IFS farmers of Dharwad (Northern transition zone): In Dharwad district, IFS farmers exhibit a strong linkage with milk cooperatives (80.00) and SAU's (71.33). Moderate linkages are observed with farmer unions/clubs (68.67), farmer friends (68.00), KVK (62.67), and private companies/ input agencies (56.67). Cotton board, Pulses board, Sugarcane associations (49.33), State Department of Animal Husbandry (47.33), State Department of Agriculture and Horticulture (46.00), and KVAFSU (44.00) have weaker linkages with IFS farmers as highlighted in figure 2.

*Stakeholders' linkage among IFS farmers of Tumkur district (Central dry zone):*The Table 5, displays that IFS farmers of Tumkur had no strong linkage with

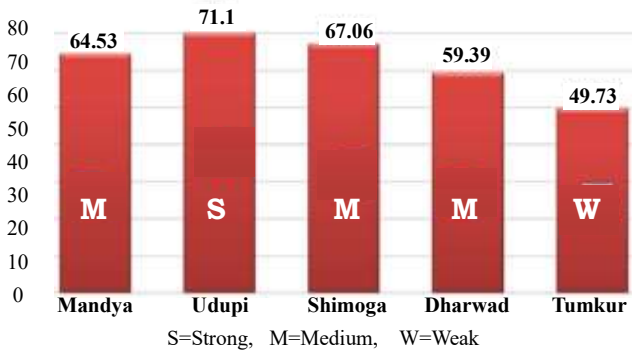


Fig.1: Overall linkage Index of respondent farmers

any of the stakeholders, whereas they had moderate linkage index with their farmer friends (Opinion leaders/progressive farmers/neighbors) (62.67), followed by KVK (62.00), State Dept of Agriculture and horticulture (50.67), Private Companies/Input agencies (53.33) and KMF (milk cooperatives) (50.67) and weaker linkage with coconut boards/ Cocoon market officials (46.00),farmer unions/clubs (44.67), State Dept of AHD (44.00), SAU (42.67) and KVAFSU (40.67).

Overall linkage Index : From figure 1, it could be seen that the results of overall linkage index are Strong (S-70.10) in case of Udupi district, Medium (M) in Shimoga (67.06), Mandya (64.53) and Dharwad districts (59.39) whereas found Weak (W) in Tumkur district (49.73).

DISCUSSION

The dynamics of key stakeholder linkages in Integrated Farming System: The results from study depicts that since young farmers are more profit oriented they try to adopt new enterprises and get updated according to the market demands, so they try to build up liaison between various stakeholders. For example, in Mandya district, young farmers have formed collaborations with Organic Mandya private limited to market their produce, in addition to their cooperative societies, APMC mandis and village markets. In Udupi district, Farmers Producer Organization focused on coconut and arecanut is led by young farmers. It was evident that some of the actors played very crucial role whereas, some other were having very little contribution in the information flow and technology transfer. KVKs played a crucial role as a region-specific information source for resolving agricultural problems and had stronger

linkage with farmers. FPO's involved in marketing agricultural products and dairy feed supplements also had strong linkages with farmers. Similarly, KVKs and SAUs, KVAFSU & SAUs maintained strong reciprocal linkages respectively as they played a vital role in disseminating benefits to farmers in the agricultural sector while private/input agencies had strong linkage with farmers. These results are in line with study from Ditty (2018). Since farmers depend on inputs like fertilizers, seeds, irrigation materials, pesticides on loan basis with private or input agencies the linkage is stronger whereas Private and public sector linkages were weak which requires strengthening. In Udupi and Shimoga built in Cultural meetings at the village level and farmers' WhatsApp groups further enhanced linkages. In Mandya, the cocoon market, sugarcane societies, KVK, and dairy cooperatives played crucial roles, establishing a strong linkage for technology dissemination. There is a medium level linkage between SDA, AHD, SAU and farmers who plays a major role in disseminating new technologies through extension systems, offering crop insurance schemes, loans, subsidies for micro-irrigation techniques, farm machinery and functioning as key financial backers for farmers. Similar results are implicated in the studies of Basera & Bhardwaj (2022), Himeur (2023), Das & Jha (2022).

Roles & Actions performed by Stakeholders in IFS as perceived by farmers: The findings indicate that most of the respondent farmers recognize the State Department of Agriculture and Horticulture as the lead stakeholder providing financial support and driving policy formulation. The department implements various schemes, including Karnataka Raitha Suraksha Pradhana Mantri Fasal Bima Yojana, Krushi Bhagya, and Pradhan Mantri Kisan Samman Nidhi. The KVK, recognized by 96.00% of farmers, plays a vital role in research-extension linkages and on-farm trials, dissemination of IFS technologies, the results are in line with Monika Wason *et al.*2022. The Animal Husbandry department of Karnataka State is effectively supporting with schemes like Pashu Bhagya offer subsidies to establish cattle, sheep, goat, pig, and poultry units, with back-ended subsidies for SC/ST farmers. The 'Kurigahi Suraksha Scheme' provides a Rs. 5,000/- ex-gratia amount for sheep rearing, and the Foot and Mouth Disease Control Programme, as expressed by 70.00% of respondents.

ICAR-KVK / State funded KVK and RSK, have been disseminating new and old information about IFS in general to the farmers to create awareness among them (96.00%). Field visits and advocating of officials from KVK & RSK in the demonstration plots of farmer's field encourages other farmers to understand and adopt the new & needful technologies (86.80%). Progressive farmers act as a para extension agents in disseminating any new technologies (67.20%) to be adopted in their area as per the needs of farmers say may be through grapevine communication, at panchayat meetings and cultural programs meeting or at their farmer associations meetings. Some of them act as brokers (24.00%) also to market the agricultural produce between other farmers and private agencies. Commodity boards/APMC, Farmer Cooperatives/ KMF, FPO's / CIG/ SHGs and Private Companies / Input agencies also play greater role in commodity trading, business up scaling and marketing through diffusion of information, Coaching regarding technical skills, mediating for broadcast of IFS technologies at different agro climatic zones. The findings are in line with the research results of Suchiradipta and Raj (2014) from their study on Agricultural Innovation Systems (AIS).

Comparative Linkage between IFS respondent farmers and other Stakeholders

Mandya district (Southern Dry Zone): Krishi Vigyan Kendra (V.C Farm) & College of Agriculture, Mandya establish strong farmer-research institute linkage through proximity, reinforced by university-led trainings. State Agriculture & Animal Husbandry departments, input agencies involve in identification of farmers, schemes, and subsidies implementation resulted in good linkage between different stakeholders.

Udupi district (Coastal zone): IFS farmers demonstrated reciprocal connections with farmer friends, facilitated by regular village meetings during every day cultural art practice (Yakshagana) by villagers. These gatherings served as forums to discuss agricultural issues, schemes, and benefits through farmer organizations and public sector entities, strengthening linkages with farmer unions. Additionally, significant ties with Krishi Vigyana Kendras (KVK), Brahmavara of Udupi district, for technical services and training. The State Department of Agriculture and Horticulture played pivotal role

in agriculture scheme implementation for farmers. Given Udupi district's focus on plantation crops, the commodity boards for Coconut, Arecanut, Cashew, spices held paramount linkages with IFS farmers for procurement, consultancy, and training. Dairy cooperatives and local milk outlets were essential for procuring milk and sharing dairy-related technologies with IFS farmers. Moderate linkages exist between public sector actors like the State Animal Husbandry Department (AHD) and State Agricultural University, Shimoga, as farmers consult them for training and information on agricultural challenges. However, KVAFSU has weaker linkages due to its focus on research and education, and farmers' hesitation to approach distant university experts. Private actors and input agencies also show weak linkages with farmers, with only few having contact with companies like CAMPCO, while others face exploitation by middlemen—an issue that needs addressing, as highlighted by Asres (2012) and Das & Jha (2022) in a similar study.

Shimoga district (Hilly Zone): Among stakeholders, farmer friends were the primary source for agriculture-related information, fostering the successful establishment of farmer unions and clubs. SHIMUL dairy cooperative societies were highly preferred channels for information on schemes, dairying, essential inputs like cattle feed and mineral mixtures etc. Also farmer societies, where all respondents held membership, organized regular training programs and monthly meetings as mentioned in research study of Smitha (2019). The SDA & SDH showed a strong linkage with farmers, maintaining direct contact through the extension system, regular field visits. The moderate linkage between KVK involves training programs, seminars, publications, exhibitions, demonstrations, field days, Krishi mela, and dairy mela conducted by KVK experts. The State Department of Animal Husbandry and KVAFSU extension system collaborate in disseminating improved technologies at the field level with technical advice and training to update the extension system. IFS farmers and various commodity boards in Shimoga, such as Arecanut, Cashew, Coconut, Coffee, and Rubber, have a strong linkage due to the predominant cultivation of these crops in the zone. The University of Agricultural and Horticultural Sciences, Shimoga, maintains a medium-level linkage, disseminating technologies through various extension methods. Private agencies exhibit less linkage attributed to factors like distance, topography, logistics, consultancy fees, and middlemen issues. However, a few private milk outlets have emerged to procure malnad gidda cow milk for marketing and value addition.

Dharwad (Northern Transition Zone): A district predominantly engaged in dairy farming within IFS, there's a strong linkage with milk cooperatives, facilitated by convenient village-level training, as reflected in study of Mohammad (2012). Strong connections exist with the University of Agricultural Sciences, Dharwad, involving experts and extension staff. Farmer friends and unions/clubs have a medium-level linkage for fulfilling farming needs. The linkage with KVK is moderate, aligning with its role in research and technology dissemination. Farmer connections with input agencies/private companies are also moderate. However, linkages with Cotton board, Pulses board, Sugarcane associations, State Department of Animal Husbandry, State Department of Agriculture and Horticulture, and KVAFSU are weaker due to logistical constraints and distance issues for district-level participation.

Tumkur district (Central Dry Zone): Majority of the farmers belonged to marginal and small farmer category and the district is drought prone area. Farmers with the alarming water scarcity are facing highly difficult situation to follow agriculture and subsidiary enterprises, results are in line with the similar study by Ramya *et al.* (2021). In the midst of high thrust of water, there is less drive for linkage among stakeholders. Hence with almost all the stakeholders, Tumkur district farmers had very weak linkage. Moderate level of linkage with farmer friends (Opinion leaders/progressive farmers/neighbors), followed by KVK, State department of Agriculture and Horticulture, Private Companies/Input agencies and KMF (milk cooperatives) had helped the IFS farmers to go with the farming systems of coconut, groundnut, ragi /millets, along with dairying, sheep and goat units with very less considerable profits.

Overall Linkage: In Udupi and Shimoga, high labor scarcity propels farmers towards mechanization and progressive farming, fostering strong collaboration among stakeholders. Cooperative farming is crucial for sustainability, urging strong linkages with farmer

unions, clubs, and public-private sector institutes. In Mandya and Dharwad, where strong linkages exist, efforts should focus on expansion. Establishing a robust research-extension-farmer linkage is vital for climate-smart IFS agriculture. In drought-hit Tumkur, public-private partnership is essential for delivering technologies and promoting IFS to mitigate climate-related losses.

CONCLUSION

The study assessed stakeholders' roles in technology transfer, awareness, facilitation, research, collaboration, training, and adoption, including actions in information dissemination, market access in IFS. While the Karnataka State extension system facilitated technology dissemination with a moderate extension-research linkage, weak links persist in identifying field-level research problems, potentially due to reliance on researcher expertise. Recommendations include increased community involvement among farmers & collaborations by forming cooperatives, FPOs, facilitating Farmer Field Schools (FFS), and organizing farmer networks. These platforms enable knowledge sharing, peer-to-peer learning, and joint decision-making, strengthening solidarity and promoting innovation. Participatory research and extension programs engage farmers in collaborative initiatives, while joint marketing efforts and multi-stakeholder platforms facilitate collective action and market access. Training and capacity building opportunities empower farmers to engage effectively with stakeholders, and regular monitoring for any agriculture programs contributes to inclusive decision-making and sustainable agricultural development.

Funding: UGC –NF(OBC) Fellowship support for conducting this research.

Declaration of competing interest: Authors have no competing interests.

Data availability: Data would be made available on request

Acknowledgement: The authors are deeply indebted to the different stakeholders of IFS who formed the sample for the study.

Authors' contribution: All the authors conceptualized and operationalized the study. The data was collected, analyzed, interpreted and written as article by the first author. The second and third author edited and revised the manuscript. All authors have read and agreed to the published version of the manuscript.

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