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Estimation of Income Risk of Small and Marginal Farmers in Tank Fed Area through Analytical Hierarchy Process (AHP)

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ABSTRACT: Marginal and small farmers in tank fed irrigation receive less compensation for loss encountered in their occupations. Hence to estimate the required compensation for the extent of income loss through various risks they have encountered Analytical Hierarchy Process (AHP) was employed. The result revealed that only 30.74 per cent and 58.66 per cent of income loss was compensated through insurance scheme in farming and Animal husbandry respectively. Additional compensation measure may be paid to small and marginal farmers due to peculiar risks encountered by them.

Keywords: Small and marginal farmer, Estimation of loss, AHP, Crop insurances.

INTRODUCTION

Farmers in tank fed irrigation used to encounter different income related risks in their occupations. To compensate the income loss, government encourage these farmers to enroll in insurance scheme like Pradhan Mantri Fasal Bima Yojana (PMFBY). Crop insurance is one of the options for farmers to manage the monitory loss due to yield loss. It contributed in stabilisation of farm production and income due to yield loss faced by the farming community. An insurance programme is effective when it induces farmers to take on more risks that they would not have taken otherwise. Farmers will take on more financial risks as insurance reduces risk in farming, a practise known as 'risk balancing' (Liang, 2014). But, recent studies indicated that the compensation measures of crop insurance coverage are very low and less than 5.00 per cent in India. For paddy and groundnut crops, the proportion of farmers reporting crop loss is significant (more than 25%), but insurance coverage is inadequate (Aditya *et al.*, 2018). Farmers earlier who were enthusiastically participating in the scheme through paying premium now are reluctant to pay premium for two reasons: first, there was delay in releasing the compensation from the insurance companies. Second the amount of compensation measure paid was inadequate. Hence, an attempt has been made to measure the total income loss of farmers when they encountered different risks. To quantify the risks Analytical Hierarchy (AHP) method was employed.

RESEARCH METHODOLOGY

The analytic hierarchy process (AHP) also known as multi-criteria decision-analysis method introduced by Satty (1980) was employed for construction of estimation of income risk. It is widely applied in outstanding works of various fields relating to best option selection, conflict solution, resource allocation and optimization of the decision-making process. In this study, the AHP is employed to establish actual contribution of the components and sub components in estimation of income risk through the steps given below and followed by (Rajeshwaran *et al.,* 2021 and Ejovi *et al.*. 2021).

The basic procedure follows for the AHP:

1. Hierarchy construction
2. Developing a pairwise comparison matrix for each criterion
3. Normalizing the resulting matrix
4. Averaging the values in each row to get the corresponding rating
5. Calculation and checking the consistency ratio

1. Hierarchy construction Hierarchy is established by breaking down the overall goal that is measures of estimation of income risk through basic elements. These fundamental elements of hierarchy construction are divided into two categories based on occupation:

farming + livestock and farming + wages. Further, the component, farming risk, is categorised into 5 different sub-components; they are production risk, marketing risk, financial risk, human resource risk, and institutional risk; and another component, livestock risk, is categorised into three sub-components; they are production risk, marketing & financial risk, and institutional risk (Roger *et al.,* 2011). The review of literature and authors' critical judgments has led to the construction of the hierarchical model consisting of different components. Making such construction helps to identify the components with their exclusive domain. Moreover, it helps to control the duplication of subcomponents.

2. Developing a pairwise comparison matrix for each criterion. The contribution of one component over another component has to be measure through psychological scale that build up through psychological continuum, by ordering the components through psychophysical method. In this way the weight score of pairwise comparison was assigned with a scale of 1-9 as depicted below.

Two items are equally important

one item is extremely favoured to another

Here, the weightage score assigned by the different experts are pooled together and average score of pairwise was worked out. The pairwise score were depicted in the matrix format

$$\text{Matrix of pair wise element} = \begin{bmatrix} C_{11}C_{12}C_{13} \\ C_{21}C_{22}C_{23} \\ C_{31}C_{32}C_{33} \\ C_{41}C_{42}C_{43} \\ C_{51}C_{52}C_{53} \end{bmatrix}$$

Sum the values in each column of the pair wise matrix$= \sum_{i=1}^{n} C_{ij}$

3. Normalizing the resulting matrix. To get the overall importance of one element over another element was worked out for average score of pairwise items in normalized matrix. To generate a normalised pairwise matrix that each element in the matrix was divided by its column total.

$$x_{ij} = \frac{C_{ij}}{\sum_{i=1}^{n} C_{ij}}$$

4. Averaging the values in each row to get the corresponding rating. The sum of the normalized column of matrix was divided by the number of criteria used to generate weighted matrix. Moreover, this average score gives the percentage contribution of particular element towards the goal.

$$w_{ij} = \frac{\sum_{j=1}^{n} x_{ij}}{n} \begin{bmatrix} W_{11} \\ W_{12} \\ W_{13} \end{bmatrix}$$

5. Calculation and checking the consistency ratio. Judges may assign the pairwise matrix scale without due consideration of relative importance of each elements. If it is so, the score one got in the early steps may not reflect the reality. To get the validity and reliability of the score, consistency check has to be carried out. The consistency ratio was calculated to make sure that the original preference ratings were consistent.

There are 3 steps to arrive at the consistency ratio:

1. Calculation of consistency measure.
2. Calculation of consistency index (CI).
3. Calculation of consistency ratio (CR).

Calculation of the consistency measure. To calculate the consistency measure, the matrix multiplication function =MMULT() is used for actual rows with average column.

1. Consistency measure is calculated by multiplying the pairwise matrix by the weights vector

$$\begin{bmatrix} C_{11}C_{12}C_{13} \\ C_{21}C_{22}C_{23} \\ C_{31}C_{32}C_{33} \\ C_{41}C_{42}C_{43} \\ C_{51}C_{52}C_{53} \end{bmatrix} * \begin{bmatrix} w_{11} \\ w_{21} \\ w_{31} \end{bmatrix} = \begin{bmatrix} C_{M_{11}} \\ C_{M_{21}} \\ C_{M_{31}} \end{bmatrix}$$

2. Consistency vector is calculated by dividing the consistency measure with average criterion weight.

$$C_{v_{11}} = \frac{1}{w_{11}}[C_{11}w_{11} + C_{12}w_{21} \quad C_{13}w_{31}]$$

$$C_{v_{21}} = \frac{1}{w_{21}}[C_{21}w_{11} + C_{22}w_{21} \quad C_{23}w_{31}]$$

$$C_{v_{31}} = \frac{1}{w_{31}}[C_{31}w_{11} + C_{32}w_{21}C_{33}w_{31}]$$

3. λ was calculated by averaging the value of the consistency vector

$$\lambda = \frac{\sum_{i=1}^{n} cv_{ij}}{n}$$

Calculation of the consistency index (CI). It was calculated by using the formula given below.

$$CI = \frac{\lambda Max - N}{N-1}$$

λ Max = averaging the value of the consistency vector

N = Number of criteria

Calculation of the consistency ratio (CI/RI where RI is a random index). It was done by following the formula given below.

$$CR = \frac{CI}{RI}$$

CI = Consistency index value

RI= Table value

Random Index (RI). The RI was obtained from the random inconsistency indices given by Satty (1980) which is furnished below.

n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

Study area. Small and marginal farmers in tank fed irrigated areas comprise the universe of this study. The multistage random sampling method was used to select the ultimate sampling units.

The study was conducted in Sivagangai district of Tamil Nadu. Which is having the highest net area of 63,749 hacters covered under tank irrigation compare to other districts of Tamil Nadu. Further, most of the small and marginal farmers were holding either livestock or wages along with farming as occupation. So, it was decided to choose 40 respondents from farming + livestock and 40 respondents from farming + wages occupations are selected. Thus, total 80 respondents from the district are selected for this study.

RESULT AND DISCUSSION

To estimate the income risk faced by small and marginal farmers, economic losses incurred in yield loss was worked out. In this regard, data pertaining to potential income earned by the small and marginal farmers are derived from reliable records such as Directorate of Economics and Statistics, Estimation of Cost of Cultivation / production & Related data from 2013 to 2018 and TNAU Agri portal. The data were further verified in triangulation with extension functionaries such as state officials and progressive farmers during the course of survey. The actual income earned by the small and marginal farmers in an annum was worked out from the data collected from respondents. The difference between the potential and actual income considered as the loss incurred by the farmers due to occurrence of risk events. This is presented in the Table 1.

The data in the Table 1 depicts the estimated loss of income incurred by the farmers in tank fed irrigation system. It could be understood that the major income loss happened in livestock (Rs.26845) followed by farming (Rs.13483) and wage employment (Rs.9700).

After arriving the total loss, it was decided to estimate the actual contribution of individual risk events through Analytical Hierarchy Process (AHP). Though in early days AHP (Khwanruthai, 2012) was used for decision making by prioritizing the best course of action from the available alternative through paired comparison method, in recent years this tool is employed for measuring estimations (Rajeshwaran *et al*., 2021). This tool is particularly useful when there is mixing up of objective value as well as judgement values to prioritize the events. Here adhering the methodology, analytical structure was worked out separately for two different categories of small and marginal farmers based on composition of occupations they were involved. In the first step, the loss incurred in two different occupations in proposition was calculated. In the second step of hierarchy construction, different weightage scores were assigned to different category of risks such as production, marketing, financial, human resources and institutional risks. Further, in third step the major risks identified related to the different categories of risks were put forth based on judgement of judges. Finally, based on the weightage score assigned by the judges the actual contribution of loss incurred was estimated in terms of money value which is presented in the Table 2 and Fig. 1-2.

From the Table 2, it could be ascertained that farmers who are holding livestock as occupation are losing Rs.26845 from their annual income. This estimated income loss are happening due to poor-remuneration through selling of livestock during pandemic period followed by diseases and unprecedent death of livestock through to the tune of Rs.9210.94, Rs.4422.74, and Rs.3197.35 respectively.

Regarding farming, farmers were losing their income mostly related to encounter of production risks followed by marketing risks. The production risks like escalation of inputs cost, high hiring cost of farm machineries, incidence of pest and diseases have dominating with the estimated losses of Rs.2117.25, Rs.1563.33 and Rs.1351.67 respectively.

Through the escalation of cost of labours, farmers loss an estimated amount of Rs.1402.97 followed by selling the produce in lower price (Rs.1188.03).

Table 1: Estimated loss in annual income of small and marginal farmers in tank fed irrigation system due to risk events.

Income source	Potential income (Rs.)	Actual income (Rs.)	Income loss (Rs.)
Farming (1.5ac)	49500	36017	13483
Livestock (Milch animal 2 No.)	96000	69155	26845
Wages Rs.450/day (258 days)	116000	106300	9700
F+L	**145500**	**105172**	**40328**
F+W	**165500**	**142317**	**23183**

Source: own survey data

Table 2: Estimation of income risks of farmers in tank fed irrigation system having the occupation of farming and livestock (n=40).

S. No.	Major components	Weightage (%)	Sub components	Weightage (%)	Actual contribution (% & Rs.)	Items	Weightage (%)	Actual contribution (%)	Actual contribution (Rs.)
1.	Farming risks	21.57 Rs.13483	Production risks	47.71	10.29 6433.26	Escalation of input cost	32.91	3.39	2117.25
						High hiring cost of farm machineries	24.30	2.50	1563.33
						Pest and disease infestation	21.01	2.16	1351.67
						Delay in release of water in tank	13.40	1.38	862.24
						Poor maintenance of tank	8.37	0.86	538.77
			Marketing risks	18.53	4.00 2497.26	Selling the produce in lower price	47.57	1.90	1188.03
						Exploitation by middlemen	29.83	1.19	744.94
						Others	22.60	0.90	564.29
			Financial risks	12.77	2.75 1721.43	Lack of credit to cover the intermediate farming operations	44.66	1.23	768.84
						Insufficient supply of loan amount from cooperative societies	31.82	0.88	547.74
						Others	23.52	0.65	404.85
			Human resources risks	13.60	2.93 1834.12	High cost of labour	76.49	2.24	1402.97
						Others	23.51	0.69	431.15
			Institutional risks	7.39	1.59 996.45	Limited supply of farm implements from govt. sectors	60.94	0.97	607.21
						Others	39.06	0.62	389.24
2.	Livestock risks	78.43 Rs.26845	Production risks	46.28	36.30 12423.05	Animal health disease	35.60	12.92	4422.74
						Sudden death of livestock	25.74	9.34	3197.35
						High cost of supplementary feed	15.30	5.55	1900.71
						Inadequacy of green fodder	13.12	4.76	1630.22
						Others	10.24	3.72	1272.03
			Marketing and credit risks	43.13	33.83 11578.79	Non remunerative price for livestock	79.55	26.91	9210.94
						Others	20.45	6.92	2367.85
			Institutional risks	10.59	8.31 2843.17	Non-availability of milk society	88.32	7.34	2511.02
						Others	11.68	0.97	332.15

From Fig. 1&2 indicate that small and marginal farmers were losing income of around Rs.10000 per annum in wage employment which receiving of less wage followed by delay in payment and unable to get steady employment have contributed to the estimated loss of Rs.4475.33, Rs.2672.56 and Rs.1433.28 respectively.

Further, the compensation paid and the compensation yet to be paid against the loss also was worked out from the primary data collected from the farmers and the consolidated account is presented in Table 3.

From the Table 3, it can be understood that an average amount of Rs. 4145.13 was paid through crop insurance for the year 2020 against original loss of income of Rs. 13483 from farming sector. Hence, it is recommended and additional amount Rs.9338 yet be paid as compensation by considering the risks peculiar to small and marginal farmers. Similarly, in rising of milch animals own amount of Rs.15748 was paid as compensation for risks encountered in the occupation against the actual loss of Rs. 26845. Hence an amount of Rs.11097 may be paid to small and marginal farmers for the peculiar risks faced by them. If the farmers get that money from compensation it leads to increase the income level of small and marginal farmers in tank irrigated system (Tlholoe, 2016).

Table 3: Estimation of Compensation paid and compensation to be paid to small and marginal farmers for income loss.

Income source	Compensation paid		Compensation to be paid	
	Rs.	Per cent	Rs.	Per cent
Farming (1.5ac)	4145.13	30.74	13483	69.26
Livestock (Milch animal 2 No.)	15748	58.66	26845	41.34

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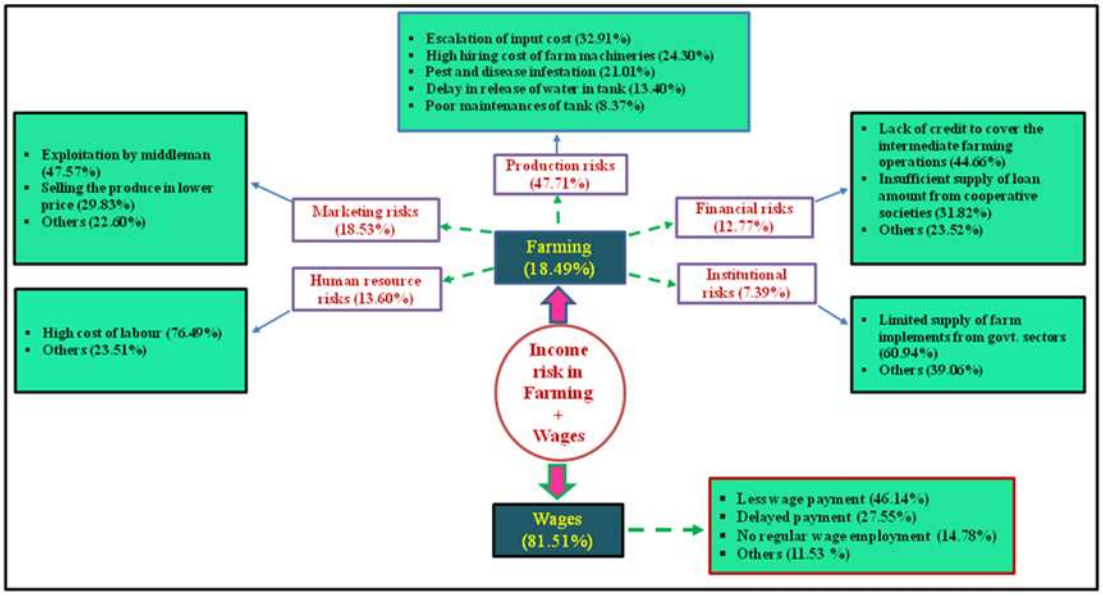

Fig. 1. Estimation of income risks of farmers in tank fed irrigation system having the occupation of farming and wages according to weightage (%).

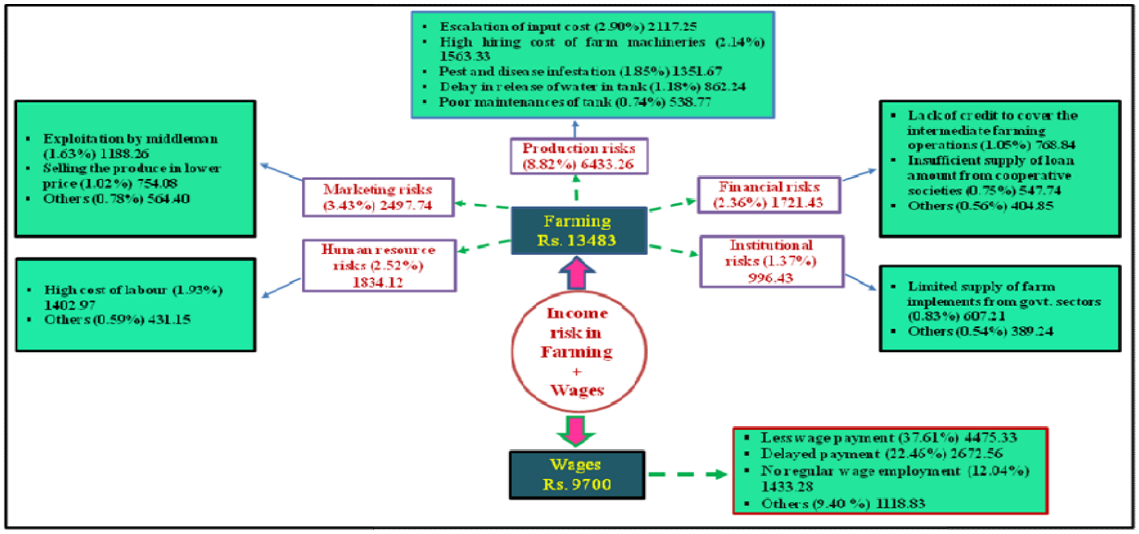

Fig. 2. Estimation of income risks of farmers in tank fed irrigation system having the occupation of farming and wages according to actual contribution (% and Rs.).

CONCLUSION

The amount of compensation received for the income loss by the small and marginal farmers are very meagre. The methodology followed for the calculation of compensation by the insurance companies is not favouring the farmers. If it continues the small and large farmers will decline to insure the crop (Matlou, 2021). The alternative methodology proposed in this paper may help to decide the amount of compensation to be paid when the farmers were faced by a set of risk.

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Conflict of Interest. None.

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