Executive summary

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Title of the thesis	:	Socio-economic analysis of Peste des Petits Ruminants (PPR): A value chain approach
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Small ruminant farming offers diversification opportunities in gaining economic and nutritional benefits for small and limited-resource farmers. Many smallholders in poor developing countries in Asia and Africa depend on goat and sheep for nutrition and livelihoods **(Chander, 2018)**. Small ruminant diseases adversely affect these benefits. Peste des Petits ruminants (PPR) is one of the small ruminant diseases and arguably the most devastating infectious disease of small ruminants in the world today **(Balamurugan *et al.*, 2013; Mariner *et al.*, 2016)**. The transboundary spread of the disease at an alarming rate over the last 15 years **(OIE and FAO, 2016)** gained global attention**.** PPR is one of the targeted diseases for many governments and their development partners to eradicate from small ruminants by implementing the PPR Global Control and Eradication Strategy (PPR-GCES) by 2030.

In India, PPR is widely prevalent and endemic in almost all parts. The disease has both social **(Evans, 2006)** and economic (**Bardhan *et al.*, 2017a**) impact across the regions in which it circulates (**OIE and FAO, 2015).** In rural areas, PPR not only adversely affects the farm families but also the value chain. Therefore, there is a need to study the work force contributed by women in raising small ruminants, the effect of PPR on small ruminant value chain, the associated factors of outbreak and the disease risk analysis. Literature review revealed that the trend of substantial increase in study on farmer's perceptions and behaviour in relation to disease control is not noticed in India. Past studies on PPR in India focused more on technical aspect of PPR vaccine followed by economic impact at farmer level in the small ruminant value chain. On the other hand, eradication mandates vaccination. Vaccination strategy needs participatory epidemiological information which helps in disease risk analysis. Considering these research gaps, the study was carried out to analyse the socio-economic impact of PPR using value chain approach with the following objectives.

- To study the perception of small ruminant value chain stakeholders on sheep and goat diseases and their control with special reference to PPR
- To ascertain the factors associated with occurrence of PPR using participatory approach
- To analyze the socio-economic impact of PPR incidence across small ruminant value chain
- To carryout the risk hotspots analysis in small ruminant value chain for effective PPR control programme (PPR-CP) intervention

An ex-post facto research design was adopted to gain insight into the chosen study. Initially, a composite index (CI) was constructed to divide the states in India into four quartiles. From the first quartile, Karnataka and Tamil Nadu were selected for the study considering their state-wide and focused area vaccination, respectively. Two outbreak districts were selected purposively from each selected state, based on the criterion that at least one PPR outbreak has been reported from that district during the previous twelve months period prior to the date of the survey. Thus, Kolar and Belagavi districts from Karnataka and Cuddalore and Tiruvallur districts from Tamil Nadu selected for this study. From each selected district, two blocks were selected. One block with villages where PPR outbreak occurred during the last one-year period prior to data collection, and one more block where outbreak did not occur was selected purposively. Thus, totally eight blocks were selected. From the outbreak blocks, one village which experienced PPR outbreak and another which did not experience outbreak during the last one-year period prior to the date of survey were selected purposively. Further, one each village from the outbreak and the non-outbreak blocks were selected randomly. Thus, a total of 12 villages were selected.

Based upon the sample size determined, 35 small ruminant rearing households from each village were selected for conducting the household survey. Thus, 210 small ruminant farmers were selected from each of the selected states. To select the stakeholders, a list of different value chain stakeholders was prepared in consultation with key informants and local veterinarians. From the list, 39, 23, 24, 21, 19 and 30 numbers of aggregators/village level traders, commission agents/middlemen, traders/sub-traders, wholesalers, retailers and restaurant owners were selected randomly to study the socio-economic impact. For conducting the participatory sessions in Tamil Nadu, different stakeholders were drawn randomly from the respective lists prepared. For

effective management of the participatory sessions, the total number of participants for each session was limited to 20-25.

The study was carried out by following appropriate research methodology to accomplish the objectives. The perception of the stakeholders was measured using ranking based on mean response. The social impact was measured by ranking based on mean rating score. The economic loss at farmers level was calculated by using formula developed by **(Singh *et al.*, 2014).** The economic loss of other stakeholders was calculated based on the data and information collected from the respondents. The PPR risk hotspots analysis in value chain for effective disease control is based on practical field applications of approaches given in a FAO working paper **(Taylor *et al.*, 2010)** and a subsequent practical framework given by **FAO (2011)** and **OIE (2019)**. Based on this approach, rating scores were obtained from experts.

1 Salient findings

1.1 Profile of small ruminant farmers

1.1.1 Farmer-specific variables

1. Farmers' age ranged between 20 and 76 years. Nearly 40.48 per cent of the total respondents belonged to young age group of 20-38 years followed by 17.62 and 41.90 per cents of the respondents belonged to old and middle age years, respectively.
2. Majority (55.95%) of respondents were female who were primarily involved in small ruminant farming and the remaining 44.05 per cent of the small ruminant flocks were maintained by male farmers.
3. Majority (71.67%) of the respondents belonged to OBC followed by SC (28.33%) and none of them belonged to either general or ST.
4. Majority (81.43%) of the respondents were married followed by unmarried (7.62%) and widower (6.43%) and 4.52 percent of the respondents were divorcee.
5. Most of the respondents (52.86%) were living as a joint family compared to nuclear family (47.14%).
6. Majority (60.95%) of the respondents belonged to medium family size (6-8 numbers). Range of family size in the study area was between three and eleven family members.

7. Maximum (24.76%) of the respondents were educated up to primary education, followed by middle school (22.62%), and high school (21.67%). Only 5.24 per cent of the respondents were graduates.
8. Range of family educational status in the study area was between 2.64 and 8.84.
9. An overwhelming majority (98.33%) of the respondents had sheep and goat farming as a primary occupation followed by agriculture with meagre proportion (1.19%) of the respondents. Nearly one-third (31.90%) had farm labour as a secondary occupation. Significantly, half of the respondents did not have any tertiary occupation.
10. Majority (55.71%) of the farmers had 1-18 years of experience followed by more than one-third (34.76%) of the farmers with 19-36 years of experience and 9.52 per cent with 37-54 years of experience. Mean experience in goat farming was 17.75 years.
11. Total annual income of the respondents ranged between ₹59,085 and 5,82,810. Near/around half (50.48%) of the respondents belonged to medium annual income (₹2,33,660-4,08,235) followed by 44.49 per cent of the farmers earned low income (≤₹2,33,660).
12. Respondents in the study area were earning up to ₹2,36,520 annually from sheep farming. Majority (41.79%) of the respondents received medium income (₹86,626.71-1,55,733.35) from sheep farming.
13. Farmers earned up to ₹2,24,840 annually from goat farming. Nearly two-thirds (65.00%) of the respondents did not keep goats. Only 28.57 per cent of the farmers earned low income (₹17,520.00-86,626.70).
14. Range of income from small ruminants was between ₹18,067.50 and 2,36,6520. Majority (53.57%) of the respondents were earned medium income (₹90884.61-1,63,702) from small ruminant rearing. Nearly one-third (31.90%) earned low income.

1.1.2 Farm-specific variables

15. Majority (84.52%) of the respondents were landless (<0.002 ha) followed by marginal farmers (9.76%).

16. Majority (50.24%) of the respondents had low livestock possession (≤4.70TLU) followed by medium livestock possession (4.71-8.80TLU) and high livestock possession (≥8.81TLU).

17. A significant proportion (41.19%) of the respondents had medium sheep possession (2.71-5.40 TLU) followed by low possession (≤2.70 TLU).

18. Respondents kept up to 7.70 TLU of goats. High percentage (92.14%) of the respondents had lesser number of goats (≤2.57TLU) followed by 7.38 per cent with medium goat possession (2.58 - 5.14TLU). Negligible proportion (0.48%) of respondents only reared goats in larger numbers ((≥5.15TLU).

19. Majority (53.57%) of the respondents had medium (3.58-6.54TLU) small ruminant units followed by 43.1 per cent with lesser number (≤3.57TLU) of goats.

20. An overwhelming majority (93.81%) of the farmers reared their animals under semi-intensive system. Only 6.19 per cent of the farmers reared their animal under extensive system.

21. Income and employment were first and second important motivation factors with Garrett mean score of 78.08 and 68.92, respectively, for keeping small ruminants in all the study villages.

22. Majority (85.00%) of the respondents had ≤5 materials including communication devices among that all the respondents had television followed by 82.62 percent of the respondents had mobile along with radio. None of the respondents had telephone.

23. An each 35.24 per cent of the farmers had semi pucca and pucca housing and 29.52 per cent of the farmer's dwelling was kacha type.

1.1.3 Gender variable

24. Nearly half (47.86%) of male respondents were decision makers on small ruminant farming and only, nearly one-fourth (24.05%) of the female members were decision makers.

25. More than one-third (35.00%) of the women had financial freedom, followed by an almost similar proportion (35.48%) did not have financial freedom. Significant proportion (29.52%) of farmers had partial financial freedom.

26. Nearly all (98.57%) of the women contributed more than 50 percent of the work force and 46.19 per cent of the women contributed ≥276.30 man-days. Their contribution was more than men farmers. Only 1.43 per cent of the men farmers contributed more than 50 per cent of the workforce. However, majority (83.81%) of the men contributed more than 25 percent medium level (25-50%) of work force in small ruminant farming.

27. An almost similar proportion of the women farmers were member (50.71%) and non-member (49.29%) of group or society in the study area.

28. An overwhelming majority 95.48 per cent women farmers were not an office bearer in any society or group. Only 4.52 per cent of women farmers were office bearers in society or group.

1.1.4 Institutional variables

29. Majority (61.90%) of the respondents had access to animal husbandry service centre within 5-10 km radius, while 38.10 per cent had access at a distance less than 5 kms.

30. The distance to livestock market from small ruminant farms ranged between 11 and 44 kms. Only 20.24 per cent of the farmers were nearer to livestock markets with a distance of ≤22 km, whereas 45.48 per cent of the respondents travelled more than 33 km to reach market for sale or purchase small ruminants.

31. Comparatively more (55.95%) proportion of farmers could not avail credit facilities, while 44.95 per cent of the respondents accessed credit facilities.

32. Nearly three-fourths (74.52%) of the small ruminant farmers could not avail credit facilities which could lead to distress sale by the farmers.

1.1.5 Communication variable

33. Notably, more than (71.19%) of the respondents did not listen to radio. Similarly, 48.57 per cent of the respondents did not listen to community radio.

34. Only 55.24 per cent of the respondents watched television once a year to know about small ruminant farming and nearly half (48.57%) of the respondents read newspaper more than once a week for the same.

35. More than half (56.90%) of the respondents used mobile phone to read text message for more than once a week.

36. Notably, each 42.14 per cent of the respondents read farm publications once in a month and attended exhibition/*kisan mela* once in 3 months.

37. Significantly, 40.24 per cent used internet more than once a week.

38. More than two-fourths (67.14%) of the respondents used social media more than once a week.

39. Half of the respondents met veterinarian fortnightly seeking information on small ruminant farming and 20.48 per cent of the respondents availed information services of subject matter specialists (SMSs) / scientists / faculties once in a month.

40. Significantly, 42.86 per cent of the respondents availed the information services offered by NGOs twice a year.

41. Half of the respondents never approached cooperative society.

42. Once in three months, 42.86 per cent of the respondents approached bank officials.

43. Significantly, 44.05 per cent of respondents contacted insurance officials twice a year.

44. Majority (82.38%) of the farmers relied on paravets for information and 17.62 per cent never relied on them.

45. Nearly one-third (30.24%) of the respondents used the information services of paravet twice a year.

46. Nearly one-fourth (24.52%) contacted with progressive farmers once in three months.

47. Farmers considered their friends as a source of information and 27.62 per cent of the farmers contacted their friends once in a week.

48. Significant proportion (40.48%) of farmers contacted feed agents twice a year.

49. An overwhelming (94.29%) of the farmers approached pharmacy person at least once in a year.

50. More than half (50.24%) of the respondents underwent training on small ruminant farming once in a year.

51. Nearly half (49.76%) of the farmers never underwent any training.

52. Almost equally, 45.24 per cent of the respondents attended a demonstration once in a year and 44.76 per cent never attended any demonstration.

53. More than one-third (36.67%) attended health camp once in a year.

54. Notably, 36.90 per cent never attended any health camp.

55. More than one-fourth (25.48%) of the farmers attended awareness meeting on small ruminant farming once in three months.

1.2 Qualitative mapping small ruminant value chain

56. Farmers directly sell their animals at farmgate and also at livestock shandy to the buyers *viz.*, traders/sub-traders, distant traders, wholesaler, retailer/butcher. If buyer and/or seller agree(s), the middleman or commission agents negotiates in purchase or sale of animals.

57. The longest value chain was 'Farmer → Aggregator → Trader/Sub-trader → Retailer/Butcher → Consumer'. The shortest value chain was 'Farmer → Retailer/Butcher → Consumer'. The rare type value chain was 'Farmer → Consumer', which exists only during festivals and disruptions in value chain.

1.3 Perception of farmers and stakeholders on sheep and goat diseases and their control with special reference to PPR

1.3.1 Perception of farmers

58. Usefulness of farmers attributes in small ruminant health received highest mean response value in overall perception and was ranked first with 0.75, 0.80, 0.81 and 0.73 respective mean response from outbreak and non-outbreak villages of Karnataka and that of Tamil Nadu followed by small ruminant disease prevention and control which was ranked second by both state farmers.

59. Self-satisfaction and earning goodwill from the buyers were ranked first with more than 0.90 mean response.

60. Herd health management practices and cooperation from all small ruminant farmers were perceived most important and ranked first with more than 0.90 mean response by the farmers belonged to both the states in control and prevention of small ruminant diseases.

61. Farmers in both the states perceived nasal and ocular discharge and high fever were important signs and ranked first with mean response of more than 0.85 in deciding on small ruminant diseases control.

62. For control of small ruminant diseases, measures such as vaccination, sensitizing nearby farmers about adverse health condition of small ruminants due onset of outbreak, proper disposal of death animals/aborted fetus and extension intervention were found essential and ranked first with mean response of 1.0

63. In Karnataka state, the measures such as proactive control measures, prompt response to reporting, adequate veterinary services were perceived most important for PPR-CP whereas farmers in Tamil Nadu, the respondents perceived prompt response to reporting as primary important in control of PPR. The mean perception response score for prioritization was 1.0.

64. In both the state farmers consult veterinarian and informally receive information from pharmacy person who were perceived as first choice with mean response score of 1.0 to know firsthand information about small ruminant diseases

1.3.2 Perception of aggregator or village level trader

65. Aggregators/VLTs from both the states perceived control programme with special reference to PPR as useful and ranked it at top (rank I with mean response score of 0.85 in Karnataka and 0.84 in Tamil Nadu).

1.3.3 Commission agent's or middleman's perception

66. Middlemen in both the states perceived credibility of small ruminant disease control information sources as most important (rank I with mean score of 0.73 in Karnataka and 0.64 in Tamil Nadu).

1.3.4 Trader's perception

67. Traders from both the states perceived the importance of credible small ruminant disease control information sources and ranked first with mean response score of 0.70 in Karnataka and 0.67 in Tamil Nadu.

1.3.5 Wholesaler's perception

68. Wholesaler in both the states perceived credibility of small ruminant disease control information sources as most important (rank I with mean response score of 0.71).

1.3.6 Retailer's perception

69. Retailers in Karnataka perceived small ruminant disease prevention and control was effective (rank I with mean response of 0.67) and information sources were credible (rank II with mean response of 0.67).

1.3.7 Restaurant owner's perception

70. The restaurant owners in Karnataka perceived small ruminant disease prevention and control was useful and ranked with highest mean response *i.e.,* 0.90 (rank I) due to the effectiveness of disease control programme with special reference to PPR (rank II with mean response score of 0.83).

1.4. Factors associated with occurrence of PPR using participatory approach

71. Simple ranking and pair-wise ranking carried out involving stakeholders of small ruminant value chain revealed that lack of skill, low income and delay or failure in animals treatment predisposed to PPR among the other individual, socio-economic and institutional factors.
72. Farmers revealed that sheep pox and PPR were considered as more severe diseases in sheep and goat, respectively. They also concluded that signs *viz.,* abortion (50.00%), diarrhoea (43.33%), nasal and/or ocular discharge (33.33%) and respiratory illness (33.33%) were the important signs for differentiating PPR from other disease.

73. Seasonal calendar prepared by farmers revealed that more PPR outbreak occurred during north-west monsoon season (October to December) and in the same season anthrax outbreak also occurred.

74. Proportional piling exercise revealed that among the small ruminant diseases, PPR disease outbreak was more followed by sheep pox. The PPR vaccination failed to protect a meagre (1.00%) of the vaccinated animals citing the incubation stage of the animal.

75. Simple ranking and pair-wise ranking revealed that among all the associated factors epidemiological risk factors were considered as most severe factors followed by socio-economic factors and the least severe factor was political factors.

1.5. Social impact due to PPR

1.5.1 Social impact of PPR among small ruminant farmers

76. The social impact of PPR at individual level clearly demonstrates that, there is an increase in approach to veterinarians by the farmers in both the states.

77. The social impact of PPR was studied at gender level and it was found that, women played vital role in PPR disease management in both the state.

78. In case of children, marginalised impact was observed in the form of decrease in their workload while other education related factors *viz,* attendance, marks in the examination, co-curricular and extracurricular activities were affected.

79. The foremost impact was, the family members were started more offerings to the god in the form of cash, commodities and ornaments to protect their animals from PPR.

80. The various farm practices which were carried out for disease management at any farm given major thrust to control spread of diseases.

81. The farmers belonged to non-outbreak villages in Tamil Nadu and outbreak and non-outbreak villages in Karnataka (outbreak and non-outbreak) state sold the small ruminant product and utilised community services and resources after recovery from PPR without any restrictions or sanctions.

1.5.2 Social impact of PPR among aggregators

82. Social impact among aggregators at individual level was more in Tamil Nadu (rank I) compared to Karnataka (rank III). The trend was reverse at gender level social impact. In both the states, impact at occupation level (rank II) and society level (rank V) was same.

1.5.3 Social impact of PPR among middleman

83. Social impact of PPR among middlemen was better reflected at gender level in Karnataka and children level in Tamil Nadu.

1.5.4 Social impact of PPR among traders

84. Social impact caused due to PPR was highest at individual level in Karnataka with mean score of 3.08 and rank followed by impact at occupational level in value chain with mean score of 2.97 with rank II.

1.5.5 Social impact of PPR among wholesalers

85. Impact was highest at society level and lowest at children level. It was followed by social impact caused due to PPR in Karnataka and Tamil Nadu was second highest at occupational level with mean score of 2.93 and 3.06, respectively.

1.5.6 Social impact of PPR among retailers

86. Social impact among retailers caused due to PPR was highest at individual level in Tamil Nadu with mean score of 3.19 and rank followed by impact at gender level with mean score of 2.88 with rank II.

1.5.7 Social impact of PPR among restaurant owners

87. Social impact among restaurant owners caused due to PPR was highest at individual level in both the states. It was followed by impact at children and occupation level with rank II and III.

1.6 Economic loss incurred

1.6.1 Economic loss incurred by farmers due to PPR

88. **Mortality loss:** Total mortality loss due to PPR in the studied sheep farms in Karnataka due to PPR was ₹1,17,000 from 42 animals and that of goat in Karnataka and Tamil Nadu was ₹1,27,000.00 and 4,69,000.00 rupees from 29 and 139 animals, respectively.

89. **Morbidity loss:** Share of morbidity loss to total loss and loss per animal due to PPR in goat was high in Karnataka (Rs.6047.62) compared to Tamil Nadu (Rs.5790.12). The present study estimated that morbidity loss contributed nearly 43.71 percent in sheep, similarly 33.23 and 36.62 per cent in goats in Karnataka and Tamil Nadu.

90. **Total loss:** Total loss due to PPR in sheep in Karnataka was ₹2,07,848.75 similarly total loss due to PPR in goat in Karnataka and Tamil Nadu was ₹1,90,198.75 and 7,39,961.25 respectively. Total loss due to PPR in small ruminants in studied states was ₹9,30,160.00 rupees.

91. **Total loss per small ruminant:** Total number of farms infected with PPR in goat was high in Tamil Nadu (20) compared to Karnataka (4) which could be due to the statewide vaccination under PPR-CP. Total loss due to PPR per sheep farm in Karnataka was ₹18,895.34 and total loss due to PPR per goat farm in Karnataka and Tamil Nadu was ₹47,549.69 and 36,998.06 rupees respectively. Total number of sheep infected with PPR was 42 and total number of goats infected with PPR was high in Tamil Nadu (139) followed by Karnataka (29) which made to a total of 210 infected animals. Total loss due to PPR per sheep in Karnataka was ₹4948.78. Total loss due to PPR per goat was high in Karnataka (₹6558.58) than Tamil Nadu (₹5323.46). Total loss due to PPR small ruminant was ₹5536.67.

1.6.2 Economic loss incurred by stakeholders of small ruminants value chain

92. During PPR outbreak, on an average 15 and 12 business days of stakeholders of small ruminant value chain were affected in Karnataka and Tamil Nadu, respectively. During the above-mentioned days, stakeholders in Tamil Nadu incurred the maximum and minimum share of loss to the total net income due to PPR. The incurred loss ranged

between 4.69 per cent (₹450) by restaurant owners and 30.23 per cent (₹3280) by aggregators in Tamil Nadu.

93. Overall, aggregators/VLTs in both the states and traders in Tamil Nadu incurred net income loss more one-fourth of their total net income. Traders in Karnataka incurred nearly one-fourth (22.88%) of their total net income. The loss incurred by retailers/butchers and restaurant owners in both the states was less than 8.00 per cent.

94. The loss incurred by the stakeholders reveals that the highest net income loss (₹13,987.50) was incurred by traders in Tamil Nadu and least loss (₹450) was incurred by restaurant owners in Karnataka.

1.7 Risk hotspot analysis

1.7.1 Identified risk pathway

95. Poor disease management, particularly non-adoption of PPR vaccination and deworming and contact of animals belong to various flocks while using community resources such as pasture land and water points were considered as the most serious pathways with qualitative score of 4.35 and 4.37, respectively.

1.7.2 Risk rating

I. Animal factors

96. Expert rating revealed that that poor health status of the animals is the highly rated risk score (3.84) with high level of probability to acquire PPR infection and cause unwanted consequences. The other risk factors of animals are also rated as high risk but less severe than their poor health status. It implies that healthy animal with any animal factor can comparatively less infected than ill-health animals.

II. Farm level management practices

97. Overcrowding of animals (risk score of 4.11) was considered as very high rated risk followed by large flock and intermixing of all age groups of small ruminant species with a respective high rated risk score of 3.89 and 3.77.

98. Poor nutrition is rated as very high risk with mean risk score of 4.05 and the remaining factors are considered as high rated risks.

99. Non-adoption of any vaccination, treatment of animals by quacks and non-adoption herd health practices are rated as very high-level risk factors with mean risk scores of 4.48, 4.31 and 4.05, respectively.

100. Poor housing is considered as a very high rated risk with mean score of 4.02. The experts rated metal fencing for animals housing is medium rated risk with mean score of 2.48.

101. Introducing males for breeding purpose from other flock has been rated as high rated risk with mean score of 3.63.

102. Not keeping records and lack of animal identification are rated as medium rated risks with a mean score of 2.92 and 2.82.

103. The rating reveals that the shed needs to be maintained hygienically, as its mean risk score (3.66) is rated as high and comparatively higher than not practicing personal hygiene (3.37) and no regular bathing to animals (2.63).

III. Institutional factors

104. Lack of routine/periodical PPR screening is rated as high level of risk with a mean score of 3.89, whereas inadequate veterinary and extension services are rated as high risks, but comparatively less severe than PPR screening.

IV Community level practices

105. Community level resource-specific practices are rated as high-level risks with near similar mean risk scores around 3.50.

V Socio-cultural practices

106. Movement of animals due to any reason is rated as high rated risks with mean score of equal to or more than 3.00 except theft which is rated as medium risk with a mean score of 2.48.

VI Entry of PPR into value chain

107. Purchase of animals PPR outbreak area is rated as very high risk with a mean score of 4.19. Notably, migratory farms are also considered as a high rated risk in PPR outbreak.

108. Holding small ruminants at value chain actor's place of farm before marketing is rated as high risk with a mean score of 3.94. Overstocking of animals while transporting is also rated as high risk with a mean score of 3.85.

109. Market with no isolation facility, uncontrolled marketing, taking unsold animal to other markets, multiple sources of sale/purchase and high quantum of marketing are rated as high-level risk with a respective score of 3.95, 3.87, 3.73, 3.73 and 3.71. Similar trend was observed in abattoir/butchery/retail shop except sharing of infected materials which is rated as very high risk with a mean score of 4.21.

110. Lack of antemortem inspection in abattoir/butchery was rated as high risk with a mean score of 3.61.

VII Exposure of animals within flock

111. Majority of the risks *i.e..,* seven out of ten, within the flock are rated as very high risk.

VIII Disease spread within and outside the flock

112. Improper disposal of waste is considered as a high rated risk with a mean score of 3.68.

IX Disease spread other than small ruminants

113. Mixing of small ruminants with other livestock is rated as a medium risk with a mean score of 2.55. Studies revealed there were less incidence in livestock species other than small ruminants.

114. Grazing/browsing in forest area poses threat to wild ruminants. Therefore, it is rated as high rated risk with a mean score of 3.31. Studies also revealed that wild ruminants acquire infection from small ruminants.

X Environmental factors

115. Environmental factors are rated as high-risk factors except mountainous area. This could be due to the reason that under favourable environmental conditions, pathogenicity of PPR virus is more.

XI Knowledge, attitude and skill (KAS) component

116. Lack of knowledge, unfavourable attitude and lack of skill components are rated as high risks except restaurant owners' favourable attitude and consumer awareness on hygienic meat of healthy animals.
117. Majority *i.e.,* seven out of ten identified risk factors of the factors related to exposure of animals within the flock are rated as very high-risk factors. A significant number of practices listed under farm level management practices and knowledge, attitude and skill (KAS) component of stakeholders of value chain were rated as medium risk factors. The remaining factors were rated as high rated risk factors. It underlines the importance of confronting risk factors involved in PPR disease occurrence and outbreak. Also, the importance of practicing herd health practices, restricting animal movement.
118. PPR risk factors matrix: of the total identified 117 risk factors, an overwhelming 89 factors feel under "high, high" matrix cell followed by 13 fell under "very high, very high" matrix cell. Similarly, 1, 2 and 12 factors fell under "very high, high", "very low, high" and "medium, medium" matrix cells.

2 Implications of the study

The following are the implications of the study.

1. Majority of the small ruminants farmers were young and middle age group, literates, married, women, belonged to OBC, living in a joint family with medium size family, keeping small ruminant farming as a primary occupation, possessing low experience, earning medium total income and medium income from small ruminant.
2. Majority of the respondents were landless, had low livestock and medium sheep possession and rearing their small ruminants under semi-intensive system with income and employment as the motivation forces.
3. An overwhelming majority of the respondents possessed communication device including television, but none had telephone. Nearly half to majority of the farmers read

newspaper, farm publications and text messages in mobile phones and used social media.

4. Women had significant say in decision-making and financial freedom. They contributed majority of the work force. Majority of them were members in social groups, but few persons were office bearers.
5. Majority of the respondents had animal husbandry service center at a short distance. However, the market institutions were distant to their place. Majority of the farmers did not have credit access and thereby, no credit availability.
6. Majority of the farmers were dependent on veterinarian, SMSs, scientists and faculties as formal information source. They also approached cooperatives seeking information.
7. Farmers directly sell their animals at farmgate and also at livestock market *(shandy)* to the buyers *viz.*, traders/sub-traders, distant traders, wholesaler, retailer/butcher and other farmers. Middlemen or commission agents are involved in animal trading, when buyer and/or seller seek their involvement for negotiating and coaxing better price. In Karnataka, APMC plays a vital role in livestock market.
8. The farmers and the aggregators perceived that usefulness of farmers attributes in sheep and goat diseases and their control with special reference to PPR was more important and effective. The other stakeholders in the value chain *viz.*, commission agents, traders, wholesalers, retailers and restaurant owners perceived credible small ruminant disease control information sources as more needed in disease control.
9. The social impact resulted from PPR outbreak among farmers and stakeholders of value chain varied across the study area.
10. The mortality loss incurred by farmers due to PPR infected animals was more than the morbidity loss. The stakeholders in Karnataka were comparatively less affected than their counterparts in Tamil Nadu.
11. 'Poor disease management, particularly non-adoption of PPR vaccination and deworming' and 'contact of animals belong to various flocks while using community resources such as pasture land and water points' posed most severe risk of PPR to the small ruminants.

12. The risks *viz.,* 'keeping healthy and PPR infected animals in same flock (no isolation)', 'increased infectious window due to more period of contact between infected and healthy animals', 'introduction of new animals into flock without quarantining', 'mixing of vulnerable and high-risk animals', 'not vaccinating against PPR', 'non-adoption of PPR vaccination at 4- and 5- months age of kids and lambs respectively' and 'non-adoption of PPR vaccination once in three years' grouped under 'exposure of animals within flock' were identified as risk factors which pose very high level of threat/risk of likelihood and impact of unwanted outcome. Also, majority of the risks caused high to very high level of risk of likelihood and impact of unwanted outcome.

3 Recommendations

Based on the findings of the study, the following recommendations were developed to formulate and refine the policies and strategies on PPR-CP strategies.

1. More skill-oriented extension outreach interventions need to be given to the small ruminant farmers, since majority of them possessed low experience.
2. Technologies of landless small ruminant production need to be developed to cater the needs of farmers.
3. Possession of communication devices by the respondents needs to be effectively utilized for offering extension and advisory services. Also, re-orienting research and extension systems in PPR-CP would be helpful to accomplish the goals of PPR-GCES. The institutions involved in offering extension services to farmers through social media and mass media need to focus on educating farmers and stakeholders of small ruminant value chain in PPR, so as to reach a greater number of farmers and stakeholders.
4. Contribution of women is more in small ruminant farming. Hence, gender-sensitive vaccination and control programmes need to be formulated and implemented. Also, technology generation and extension intervention need to be carried out with an emphasis on women,
5. The nearby animal husbandry service center has to offer need-based extension services and do needful to make a network involving all the value-chain and service-providing

stakeholders with the farmers to overcome the constraints related to credit facilities and distance to market

6. Capacitating formal extension service providing functionaries on application of next generation extension tools and the New Extensionist Learning Kit (NELK). The role of farmer producer organizations (FPOs) or cooperative societies have to be used to support PPR-CP. Small Farmers' Agribusiness Consortium (SFAC) and National Bank for Agriculture and Rural Development (NABARD) support has to be extended and strengthened to encourage and support for FPOs.
7. Rules and regulations on animal movement, marketing and slaughtering needs to be revised according to the strategy developed by PPR-GCES
8. The focus of extension intervention has to be extended to all the stakeholders across the value chain. Extension policies need to be developed or revised in a manner that inclusion of all stakeholders of small ruminant value chain as their target beneficiaries, beside farmers.
9. Social impact caused due to PPR across the value chain has to be taken into account while formulating or revising PPR-CP policies.
10. Attending an outbreak to control the disease locally in the outbreak area needs swift action and extra resources especially labour, time, logistics, vaccine, medicines and extension teaching aids. Hence, the State Animal Husbandry Department has to be provided with required resources to attend outbreaks. Further, the veterinarian in-charge has to be supported with additional inter- and intra-departmental human resources. Trained human resources from ICAR institutes, SAUs, SVUs and CAUs can contribute to outbreak area by rendering the needy services to the people. Thereby, the researcher could get first-hand information on epidemiology of the diseases and the extensionists could identify the field level problems related disease and associated factors responsible for outbreak and control.
11. Period or season, during which the demand for and consumption of small ruminant meat and other products is less, may be considered for pulse vaccination against PPR in small ruminants. Capacitating field veterinarians on diagnosing PPR using PPR diagnostic kits like pen-side test which gives results in twenty minutes. The institutes such as ICAR-

IVRI which is pursuing continuous research on PPR need to focus its thrust on resource-saving field level PPR diagnostic kits.

12. Community-based health system, participatory disease search and alternative disease surveillance involving farmers and migratory farmers need to be developed and strengthened. The stakeholders in small ruminant value chain have to be capacitated to involve them in community disease surveillance.

4 Future area of research

Based on the findings and interpretation the followings have been recommended as the areas of research in future.

1. Impact of PPR research output and control programmes on employment and income of farmers, small ruminant productivity and food security
2. Emerging use of techniques such as system dynamics modelling (SDM) for making and analyzing policies in PPR control and eradication
3. Study on the influence of value chain actors and services-providing stakeholders who has direct or indirect role in PPR-CP
4. Role of pastoral community in PPR control programmes and the scope of using them as an informal information source
5. Scope of incorporating FPOs and social groups in PPR-CP and the measures use their efficiency in PPR-CP
6. Distributional benefits among core actors of small ruminant value chain and consumers due to PPR-CP according to prevailing market elasticity
7. Estimation of the net returns from controlling PPR considering the resource spent and according to the reduction in rate of mortality and morbidity
8. Impact study of PPR-CP to estimate the changes in the national income commensurate with PPR outbreak at macro level and know its contribution in national economy
9. Study on adoption gap in PPR vaccination *vis-à-vis* vaccination against other small ruminant diseases, reasons for adoption gap and associated/determining factors to improvise the PPR-CP and bring all the small ruminant under coverage of the programme

10. Risk analysis on regional, national, global and other service providing stakeholders
11. Extending the same study to wider area covering all the agro-climatic zone of India to replicate the results
12. Exploring the scope of eradicating other diseases while implementing PPR-CP

The results of the study can help the government and policymakers in developing suitable strategies for implementing and extending PPR-CP across India.