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**Analysis of factors influencing adoption of cattle management technologies by communal farmers in Northern Namibia**

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**Abstract**

Cattle play an important socio-economic role in the livelihood of communal livestock farmers in Namibia.  This study examines the socio-economic determinants of adoption of improved livestock management practices among communal livestock farmers in northern Namibia. Data for the study were obtained through an extension questionnaire survey of farmers in northern Namibia, out of which a sample of 468 communal livestock farmers were used in this study. Descriptive statistics and a linear regression model were employed to analyze the data.

The results revealed that about five out of 10 livestock management practices disseminated to farmers were adopted on farms.  Castration and vaccination were the most adopted. Dehorning, feeding cut crop residue and livestock marketing were the least adopted. Regression analysis indicated that adoption of livestock technologies increased with education, off-farm income, farmer training in animal health, and a farmer residing in Oshana and Ohangwena regions. On the other hand adoption of livestock technologies decreased with distance from the extension office and for a farmer residing in Omusati region. This implies that farmers located farther away from the extension offices are less likely to adopt improved livestock technologies.

The findings imply that to increase adoption of improved technologies, efforts should be made to enhance access of farmers to education or literacy programmes, to off-farm income generating activities, and training in animal health care. Further research is needed to identify the constraints and key location-specific factors causing low adoption of certain technologies in some northern regions.

**Key words:** adoption index, livestock management practices, multiple regression model, socio-economic factors

 **Introduction**

Almost 70% of the population in Namibia is found in the northern communal areas and depends directly or indirectly on crop-livestock farming for livelihood. Livestock plays an important socio-economic role; it is a source of cash income, meat, milk, draft power, it is a symbol of wealth, social status and prestige and a safeguard against crop failure. Households keep mainly goats, some sheep, a few pigs and chickens but cattle are the major form of livestock (Matanyaire 1996). The traditional cattle rearing system is characterized by low input, traditional management system, with low productivity as indicated by  low calving rates, high mortality and low off-take rates for meat and milk. Despite these constraints, livestock farming has been identified as an important sub-sector with great potential to contribute to improved farm incomes, household food security and poverty alleviation among rural households in Namibia (Ministry of Agriculture, Water and Rural Development 1995). In this regard, a number of strategies aimed at raising productivity of livestock and enhancing its contribution to economic development have been attempted by the Government and its development partners since the early 1990s (Ministry of Agriculture, Water and Rural Development 2004). Among the efforts used has been the provision of extension services by the Directorate of Extension and Engineering Services in the Ministry of Agriculture, Water and Forestry. The Extension Directorate has been promoting adoption of improved livestock management technologies among communal livestock farmers in the four northern regions of Ohangwena, Omusati, Oshana and Oshikoto. These improved livestock practices or technologies included: (1) castration, (2) dehorning, (3) vaccination against contagious diseases, (4) salt block supplementation, (5) mineral lick supplementation, (6) urea-treated straw supplementation, (7) cut crop residues supplementation, (8) purchased feed, (9) selective feeding according to age, health and expected role, and  (10) formal livestock marketing practices.

For policy design and effective management of extension programmes, information on the extent of adoption of disseminated technologies and understanding of socio-economic determinants of adoption of such practices are important.  However, little is known about the level of adoption and the determinants of adoption of improved livestock practices by farmers in the northern communal regions. Therefore, this study was undertaken to investigate the extent of adoption of improved livestock management practices and to determine the socio-economic factors which influence the adoption of improved livestock practices among communal cattle farmers in northern Namibia.

**Theoretical approach**

The technology diffusion and adoption literature suggests that many different attributes of individuals may influence them to act in different ways. Studies by Feder et al (1985); Rahm and Huffman (1984) and Baidu-Forson (1999) suggest that adoption behavior of farmers is explained by farmer attributes, farm attributes, infrastructure attributes and perceptions about agricultural technologies. According to Rogers (1995), socioeconomic characteristics, personality values and communication behavior of individuals influence their way of adopting innovations such that some individuals adopt innovations earlier than others.

Numerous studies have examined the influence of socio-economic variables on farmers’ adoption decisions of agricultural technologies using either the probit/logit model (Rahm and Huffman 1984; Kabede et al 1990, Kaliba et al 1997) or the ordinary least squares linear regression model ((Rezvanfar  2007; Rezvanfar and Arabi 2009; Mafimisebi et al 2006; Rahman 2007). The linear regression model has a continuous dependent variable, while the probit or logit model involves a binary dependent variable. In these models, the dependent variable is specified as a function of farmer-specific attributes (e.g. gender, age, experience, education, household size, income, extension contact), and farm attributes (e.g. farm size, farm type, location). Usually the choice of variables included in these models is not based on any strong theoretical grounds but are guided by past studies and experience.

**Materials and methods**

In this paper, the linear regression model was used to determine the factors influencing the adoption of livestock management practices. The dependent variable is the adoption index which is expressed as a percentage of practices adopted out of a specific maximum of livestock management technologies (Rahman 2007; and Mafimisebi et al 2006). The empirical model was specified as:

Yi = β0 +  β1GENDERi + β2AGEi + β3EDUCi + β4EXPRi + β5FLABORi + β6CATTLEi + β7CRPLANDi + β8OFFINCi + β9DISTi + β10FEDGRPi + β11TRAINEDi + β12OHANGWENAi + β13OMUSATIi + β14OSHANAi + β15OSHIKOTOi + εi.

* Yi is the dependent variable. It is expressed as a percentage of livestock management practices adopted out of a given maximum of 10 practices.  The definitions of selected independent variables used in the model with their expected signs are presented below:
* GENDER is expressed as a binary variable with 1 if the producer is male, 0 otherwise. Expected sign for gender is ambiguous.
* AGE is expressed as a categorical variable, with 1 if producer is 15-30 years, 2 if 31-45 years, 3 if 46-60 years, and 4 if above 60 years old. Age is assumed to have uncertain effects on adoption.
* EDUC is a binary variable with 1 if producer has high school education and above, 0 otherwise. Education is hypothesized to have a positive effect on adoption.
* FLABOR is a categorical variable for family labour with 1 if below 3, 2 if 3-5,  and 3 if above 5 family workers.  Labour is assumed to have a positive effect on technology adoption.
* EXPR is a categorical variable for experience, with 1 if <5 years, 2 if 6-10 years, 3 if 11-20 years, and 4 if above 20 years farming experience. Experience is assumed to have a positive effect on adoption.
* OFFINC is a binary variable with 1 if farmer has off-farm employment income and 0 otherwise. It is assumed to be positively related to adoption.
* CATTLE is a categorical variable for herd size with 1 if 1-10, 2 if 11-30, 3 if 30-50 and 4 if above 50 cattle. Cattle herd size is expected to have a positive effect on technology adoption.
* CRPLAND is a categorical variable for crop area, it is 1 if crop area <3ha, 2 if 3-7ha, and 3 if above 7 hectares. It is assumed to have an uncertain effect on adoption.
* FEDGRP is a binary variable with 1 if the producer is a member of an Extension FED group, and 0 otherwise. It is assumed to have a positive effect on adoption.
* TRAINED is a binary variable with 1 if the producer attended training in animal health, 0 otherwise. It is expected to be positively related to adoption.
* DIST is categorical variable for distance with 1 if located 0-5km, 2 6-10km, 3 if 11-20 km, 4 if above 20 km from ADC. It is assumed to have a negative effect on adoption.

The model was estimated using cross-section data obtained from a 2003 Extension impact baseline survey of communal farmers in the north central regions of Namibia conducted by the European Union (EU) funded (8th European Development Fund) Regional  Extension Management Programme (REMP) in the Ministry of Agriculture and Rural Development. The original survey sampled a total of 840 communal crop-livestock farmers using a combination of multi-stage and systematic sampling procedures. A sub-sample of 468 livestock keeping households was taken from the full sample and used in this study. The sub-sample of livestock farmers consisted of 20% farmers from Ohangwena, 24% from Omusati, 26% from Oshikoto and 30% from Oshana. The survey was conducted by trained enumerators and supervised by extension staff who were trained in the survey methods prior to undertaking the survey. A pre-tested questionnaire with closed-ended questions was used to capture information from farmers on socio-economic characteristics such as farmer characteristics, the farm, extension contact, awareness and adoption of selected improved livestock farming practices, including feeding, castration, dehorning, health care and marketing which are considered in this paper.

The ordinary least squares (OLS) technique was used for estimation of the linear form of the regression model. Some descriptive statistics (e.g., frequencies in percentage) were also computed for the selected variables. The linear regression model and descriptive statistics were estimated using SPSS version 15.

**Results and discussion**

**Characteristics of surveyed livestock farmers**

The distribution of farmers according to gender, age, and education level is shown in Table 1.

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| **Table 1.**  Gender, age, and education level of surveyed farmers |
| **Characteristic** | **Category** | **Ohangwena, %** | **Omusati, %** | **Oshikoto, %** | **Oshana, %** | **Average, %** |
| Gender | Female | 39.4 | 62.7 | 62.0 | 69.7 | 60.0 |
|   | Male | 60.6 | 37.3 | 38.0 | 30.3 | 40.0 |
| Age of respondent  | 15-30 years | 16.8 | 21.8 | 28.9 | 16.2 | 20.9 |
|   | 31-45 years | 11.6 | 11.8 | 19.0 | 21.1 | 16.5 |
|   | 46-60 years | 14.7 | 18.2 | 13.2 | 26.1 | 18.6 |
|   | >60 years | 56.8 | 48.2 | 38.8 | 36.6 | 44.0 |
| Education level  | No school | 37.9 | 24.5 | 9.90 | 6.30 | 17.9 |
|   | Primary | 37.9 | 66.4 | 59.5 | 72.5 | 60.7 |
|   | Secondary | 22.1 | 6.40 | 29.8 | 16.2 | 18.6 |
|   | Tertiary | 2.10 | 2.70 | 0.80 | 4.90 | 2.80 |

Majority of the farmers were female in all the regions except Ohangwena. The age distribution pattern is similar across the regions, with majority of farmers being above 60 years. The education level of these livestock farmers is generally low, only 21% have high school education or better, 61% primary education, and 18% have no formal education. Ohangwena has the highest percentage of farmers with no formal education but it is second in terms of the highest percent of farmers with secondary education.

Table 2 shows frequency distribution of farmers according to experience, income sources, extension group membership and training in animal health.

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| **Table 2**.  Level of experience, income sources, extension group and training of surveyed farmers**.** |
| **Characteristic** | **Category**  | **Ohangwena, %** | **Omusati, %** | **Oshikoto, %** | **Oshana, %** | **Average, %** |
| Farming experience  | <5 years | 2.10 | 1.80 | 19.8 | 2.8 | 6.90 |
|   | 6-10 years | 9.60 | 6.40 | 19.0 | 8.5 | 10.9 |
|   | 11-20 years | 12.8 | 16.4 | 21.5 | 27.5 | 20.3 |
|   | >20 years | 75.5 | 75.5 | 39.7 | 61.3 | 61.9 |
| Income sources: | Business | 13.7 | 23.6 | 34.7 | 6.30 | 19.2 |
|   | Salary | 20.0 | 38.2 | 40.5 | 43.0 | 36.5 |
|   | Pension | 62.1 | 60.9 | 50.4 | 47.9 | 54.5 |
| FED group member | % | 44.2 | 51.8 | 8.30 | 9.90 | 26.3 |
| Trained in animal health | % | 21.1 | 11.8 | 11.6 | 14.1 | 14.3 |

Most farmers (62%) have experience of over 20 years in cattle farming, while 20% of farmers have experience of between 11 and 20 years. Oshikoto region has the highest percentage of farmers with less than 5 years of experience and the lowest percentage of farmers with more than 20 years of experience. Main sources of off-income are pension (54%), off-farm employment (36%), and petty trading also referred to as small business (19%). Oshikoto at 34.7% has the highest percentage of farmers running small businesses with the lowest being Oshana. About 26% of farmers receive extension services through membership in the farmer extension development (FED) group. The majority of farmers in FED groups are in Omusati (51%) and Ohangwena (44%). Overall almost 14% of farmers have undergone training in livestock disease prevention, diagnosis and treatment conducted by the extension staff. Ohangwena at 21% has the highest percentage of those trained in animal health issues followed by Oshana (14%), and the lowest was Oshikoto (11.6%) and Omusati (11.8%). This type of training is crucial for giving farmers some exposure regarding the importance of most of the livestock technologies under study.

**The characteristics of farms**

The distribution of farmers according to family labor size, cattle herd size, crop area and distance from ADC is shown in Table 3.

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| **Table 3.**Level of  family labor size, cattle herd size, crop area and distance of farms |
| **Characteristic** | **Category** | **Ohangwena, %** | **Omusati, %** | **Oshikoto, %** | **Oshana, %** | **Average, %** |
| Farm family workers  | <3 | 11.6 | 18.2 | 24.8 | 14.1 | 17.3 |
|   | 3-5 | 47.4 | 40.9 | 34.7 | 43.7 | 41.5 |
|   | >5 | 41.1 | 40.9 | 40.5 | 42.3 | 41.2 |
| Cattle herd size | 1-10 | 62.1 | 53.6 | 40.5 | 36.6 | 46.8 |
|   | 11-30 | 29.5 | 37.3 | 40.5 | 54.2 | 41.7 |
|   | 31-50 | 8.40 | 7.30 | 11.6 | 9.20 | 9.20 |
|   | >50 |   | 1.80 | 7.40 |   | 2.40 |
|  Crop area, ha | <3 | 66.0 | 29.1 | 22.3 | 21.8 | 32.5 |
|   | 3-7 | 31.9 | 66.4 | 66.9 | 69.7 | 60.6 |
|   | >7 | 2.10 | 4.50 | 10.7 | 8.50 | 6.90 |
| Distance from ADC | < 5Km | 4.20 | 33.6 | 6.6 | 23.2 | 17.5 |
|   | 6-10Km | 47.4 | 50.0 | 10.7 | 28.9 | 32.9 |
|   | 11-20Km | 31.6 | 16.4 | 38.8 | 33.8 | 30.6 |
|   | > 20Km | 16.8 | 0.0 | 43.8 | 14.1 | 19.0 |

It is clear from Table 3 that farmers depend heavily on family labor for performing farm operations. About 41% of farmers had 3 to 5 workers as family labor, 42% had more than 5 workers, and 17% had less than 3 workers. Forty-seven percent of the farmers keep between 1 and 10 heads, 42% own 11 to 30 heads of cattle and only a few farmers (2.4%) own more than 50 heads of cattle. The exception is for Oshana where majority of farmers own 11-30 heads of cattle. Table 3 shows that 61% of the farmers own between 3 and 7 ha of crop area and a third of farmers cultivate more than 7 hectares. Only 7% of farmers own crop fields that were greater than 7 ha in size. In Ohangwena, 66% of the farmers own plots less than 3 ha. The majority of farms are located between 6 and 20 km from the extension station. 17. % of surveyed farms where within 5 km radius from the ADC and 19% were more than 20 km away from the ADC. In Oshikoto, the majority of farms are located more than 20 km from the ADC while in Omusati no farm is located over 20 km from the ADC.

**Types of innovations adopted and adoption score**

A total of 10 livestock management technologies listed in Table 4 were disseminated by extension staff for adoption by livestock farmers in the four regions.  There are notable similarities and some differences in the adoption levels of technologies within regions and across regions.

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| **Table 4.**  Percentage distribution of farmers by region and by type of innovation adopted  |
| **Innovation** | **Ohangwena****(n=95)** | **Omusati****(n=110)** | **Oshikoto****(n=121)** | **Oshana****(n=142)** | **Total****(N=468)** |
| 1.Dehorning  | 15.8 | 7.3 | 7.4 | 27.5 | 15.2 |
| 2. Castration  | 91.6 | 99.1 | 95.0 | 95.1 | 95.3 |
| 3. Vaccination  | 98.9 | 97.3 | 93.4 | 95.8 | 96.2 |
| 4. Salt block  | 100 | 10.0 | 49.6 | 93.0 | 63.7 |
| 5. Mineral lick  | 96.8 | 11.8 | 46.3 | 97.9 | 64.1 |
| 6. Urea-treated straws  | 98.9 | 13.6 | 50.4 | 98.6 | 66.2 |
| 7.  Cut crop residues  | 17.9 | Na | 4.10 | 38.0 | 16.2 |
| 8. Purchased feeds ( hay) | 93.7 | 13.6 | 49.6 | 97.9 | 64.7 |
| 9. Rations supplied selectively | 84.0 | 6.0 | 20.6 | 88.7 | 50.7 |
| 10.  Marketing  | 16.8 | 16.4 | 31.4 | 27.5 | 23.0 |
| Mean Adoption level, % | 71.4 | 27.5 | 44.7 | 75.9 | 55.6 |

Table 4 shows that in the four regions, the two most highly adopted improved management technologies were castration (95%) and vaccination (96%) while the least adopted technologies were dehorning (15%), cut crop residue supplementation (16%), and livestock marketing (23%).

Ohangwena and Oshana regions have similar technology adoption levels.  Seven out of 10 technologies have adoption rates between 84% and 100%.  The exceptions are for dehorning, cut crop residue, and marketing with adoption rates of 16 to 18% in Ohangwena and from 27.5 % to 38% in Oshana. In Oshikoto, the most adopted technologies were castration (95%), vaccination (93.4%), followed by moderate adoption levels of around 50% for urea-treated straws, mineral lick, salt block and purchased feed supplementation. It is worthy to note that Oshikoto had the highest adoption level of livestock marketing while Omusati had the lowest. Although Omusati relative to other regions had the highest adoption level for castration (99%), it was the region with the lowest  mean adoption level (27.5%) and  the lowest adoption levels for most technologies including cut crop residues (0%), dehorning (7.3%), salt block (10%), mineral lick (12%), urea-treated straw (13.6%), purchased feed (13.6%), selective feeding rations (6%), and livestock marketing (16%).

Table 4 shows that Oshana recorded the highest mean adoption level of 75.9%, followed by Ohangwena (71.4%), then Oshikoto (44.7%) and lastly Omusati (27.5%).  The mean adoption level of 75.9% for Oshana implies that 7.59 farmers out of 10 in Oshana had adopted an improved livestock technology. The high adoption levels for Oshana are consistent with high literacy rate (93.7%). The low adoption rates found in Omusati and Oshikoto seem to confirm that adoption rate is very poor in developing countries (Mafimisebi et al 2006; Raj and Knight 1977; World Bank 1993).

**Results of the regression analysis**

The multiple regression analysis was performed to determine the effect of 10 independent variables on levels of adoption of improved technologies in cattle farming.  The linear form of the regression model was chosen as the lead equation in terms of economic, statistical and econometric criteria. The result of the regression analysis is presented in Table 5.

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| **Table 5.**Multiple regression analysis of effects of socio-economic factors on adoption index of improved livestock management technologies |
| **Variable** | **Coefficients** | **Standard Error** | **T-value** | **Sig.** |
| Constant | 43.3\*\*\* | 4.98 | 8.67 | 0.00 |
| Gender | 0.90 | 1.56 | 0.58 | 0.56 |
| Age | 0.58 | 0.78 | 0.74 | 0.46 |
| Education (Secondary) | 3.89\* | 1.99 | 1.95 | 0.05 |
| Experience | 0.03 | 0.99 | 0.03 | 0.97 |
| Family labour | 0.19 | 1.03 | 0.19 | 0.85 |
| Cattle herd size | 1.03 | 1.01 | 1.02 | 0.31 |
| Crop area  | -0.22 | 1.28 | -0.17 | 0.86 |
| Off-farm income  | 2.55\* | 1.56 | 1.64 | 0.10 |
| Distance from ADC | -1.59\* | 0.84 | -1.89 | 0.06 |
| FED group member | 0.04 | 1.85 | 0.02 | 0.98 |
| Trained in animal health  | 4.25\*\* | 2.09 | 2.03 | 0.04 |
| Ohangwena  | 25.9\*\*\* | 2.50 | 10.3 | 0.00 |
| Omusati  | -18.5\*\*\* | 2.62 | -7.1 | 0.00 |
| Oshana  | 30.1\*\*\* | 2.13 | 14.2 | 0.00 |
| *Adjusted R2=0.63,  F=57.3\*\*\* ;   N=465 ;  \*\*\* significance level at 1%, \*\* at 5%, and \* at 10%.* |

The coefficient of determination (adjusted R-square= 0.63) indicates that 63% variation in the overall adoption index of improved livestock technologies was explained by the 10 variables included in the model. The results in Table 5 show the important factors influencing adoption of improved livestock technologies by communal livestock farmers in the study area. All the coefficients have the expected signs. Only those coefficients associated with statistically significant variables at the 10-percent level or better are discussed.

The coefficient for high school education is found to be significant (P ≤ 0.10) and positively related to adoption level.  Controlling for other factors, the coefficient of 3.89 means that high school education would increase adoption rate by 3.89. In other words the more educated the farmer the higher the adoption of livestock technologies. Education makes people to realize the importance and benefits of adopting new technologies. Therefore educated people can be more willing to adopt and apply the new innovations in their farms. The high adoption rates at Oshana observed in the current study can to some extent be attributed to high literacy rate of farmers.

Access to off-farm employment income has a significant (P ≤ 0.10) positive effect on adoption of livestock technologies.  This entails that increased access to off-farm employment income can lead to increased adoption of livestock technologies.  One explanation for this result is that off-farm income  provides  supplemental income to finance technology expenditures for example: purchase of  salt block, urea, mineral lick, hay and small tools for dehorning and castration. This is consistent with the findings of Ward et al (2008) that off-farm income was a significant factor affecting the probability of adopting several cow-calf production practices.

As expected the coefficient for training in basic animal health offered by extension staff had a significant (P ≤ 0.05) positive effect on the adoption rate of livestock technologies. The coefficient of 4.25 for training means that training farmers in basic animal health will increase the adoption rate of livestock technologies by 4.25 percent. Farmers as individuals are known to gain from access to improved information provided through extension training (Birkhaeuser et al 1991). Similarly, the availability of extension education makes a substantial contribution to motivating adoption or intensity of use of improved technologies (Baidu-Forson 1999).

The distance from the ADC has a significant negative (P ≤ 0.10) influence on the adoption of livestock technologies. An increase in distance causes a decrease in adoption level by 1.58 percent. The ADC is usually strategically located within the farming areas and it is the place where the local extension worker is stationed. As distance from the ADC increases, livestock technology adoption decreases because this causes transport cost incurred in obtaining information on technologies and inputs to increase. Farmers are less likely to adopt the livestock technologies as the distance increases from the ADC.

Regarding the regional effect, the results show that living in Ohangwena and Oshana relative to Oshikoto the default region, positively affects the farmer to adopt improved technologies. While living in Omusati has a negative effect on adoption. These results imply that farmers in Ohangwena and Oshana have adoption scores that are higher by 25.8 percent and 30.1 percent respectively compared to Oshikoto (the omitted region). The adoption rates in Omusati are 18.5 percent lower than Oshikoto. The regional differences in adoption of various technologies may be due to differences in agro-ecological conditions, natural resource endowments, extension coverage and infrastructure. However, further discussion of these regional differences in adoption is beyond the scope of this study.

**Conclusions and recommendations**

* There were ten livestock management technologies adopted by the sampled farmers.  The most adopted technologies were castration and vaccination while dehorning, crop residue feeding and livestock marketing were the least adopted. Oshana (76%) and Ohangwena (71%) had high mean adoption rates compared to Oshikoto (45%) and Omusati (28%). Overall the mean adoption rate was 56%, indicating that about 6 farmers out of ten had adopted a livestock technology
* Econometric analysis using the linear regression model showed that adoption was positively affected by education, off-farm income, training in animal health and farmers living in Oshana and Ohangwena. On the other hand, an increase in distance from the extension station and a farmer residing in Omusati region caused a decline in adoption of livestock technologies. The other factors such as gender, age, experience, family labor size, cattle herd size, crop area, and extension group had no significant effect on adoption of livestock technologies in the study area.
* To increase the adoption of livestock technologies and improve productivity of small-scale farmers, there is a need to improve farmers’ level of education, farmers’ access to off-farm income, and access to training in animal health care.
* For Omusati and Oshikoto where the overall adoption rates are lowest, further research is required to identify the key constraints to adoption so that corrective measures can be found which can be used to improve adoption of technologies.
* The technologies with low adoption levels should also receive special attention in extension in terms of educating the farmers on the benefits of adopting such practices and where possible creating a conductive policy environment to encourage farmers to adopt such technologies.
* More innovative extension strategies are required in order to improve access to extension services for farmers in distant locations and in regions with low adoption levels. This could include employing more cost-effective extension methods such as demonstrations, group meetings and mass media methods like the radio.
* If group extension methods are to be used to improve access to extension services for distant farmers, these should be backed up by relevant messages and technologies which address the needs of livestock farmers.

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