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PROJECT DEVELOPMENT ASSESSMENT : MINERAL ELEMENTS LIMITING SHEEP PRODUCTION IN CHINA : PROJECT 8911

Murray Fearn*

Technical editor : Chris Tweddell

* Project Economist, ABARE (formerly ANUTECH/ACIAR)

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1. INTRODUCTION

ACIAR Project 8911, 'Mineral Elements Limiting Sheep Production in China', addresses the issue that inadequate supplies of essential minerals to grazing sheep in northern China have a significant detrimental effect on the production of those animals. This problem was identified through the results of a previous ACIAR project, PN 8454 'Mineral Nutrition in Small Ruminants in north-west and north-east China'. Project 8454 found inconclusive evidence of inadequate mineral intakes in grazing sheep at three sites in northern China. Project 8911 proposes to determine the extent of the mineral deficiencies in grazing sheep in northern China and develop appropriate methods of providing supplements to grazing sheep. The research is to be undertaken in conjunction with Chinese scientists. The experimental work will examine nutrient deficiencies at multiple sites in the provinces–regions of Xinjiang, Gansu, Inner Mongolia, Jilin and Heilongjiang. These regions and provinces in north-west and north-east China account for over 67% of all fine wool and semi-fine wool sheep in China (Copland 1987). Figure 1 indicates the five regions and provinces included in the project.

2. WOOL AND SHEEP MEAT PRODUCTION IN CHINA

Table 1 shows the output of sheep/goat meat, mutton and wool for the period 1961 to 1987. This is graphed in Figure 2. Mutton production has shown a sevenfold increase in this period while growth in clean wool has not been as dramatic for the same period.

In China, wool and mutton are generally produced from dual purpose sheep, where farmers respond to the relative prices of wool and meat. From 1980 to 1987, greasy and clean wool production rose 18.8% and 17.9% respectively while mutton production increased 62%. This occurred in an environment of declining sheep numbers.

Wool production is a function, amongst other factors, of sheep numbers. During the period 1980-1987, sheep numbers fluctuated between 109.5 million sheep (1981) and 94.2 million sheep (1985). A loose inverse relationship exists between sheep numbers (and therefore wool production), and mutton production where a decline in sheep numbers from 1982 to 1985 was reflected in a fall in wool production and an increase in mutton production. This was a consequence of poor profitability in the wool industry with depressed wool prices and rising production costs, and with more favourable meat prices, sheep farmers substituted into meat production by slaughtering their animals (Chey 1988).

However, it should be noted that raw wool production per animal has been steadily increasing over the period from 1.65 kg of greasy wool per head to 2.04 kg/head. This translates into a 24% rise in raw wool yield per head but is still well below the average of leading producing nations such as Australia and Argentina as well as the world average (see Table 2).

Table 1 shows the production breakdown of China's wool output in three broad wool types. The majority of the wool clip is from fine and semi-fine woolled sheep (69% in 1987) with the remainder produced from the coarse wool breeds.

Figure 1. Provinces included in ACIAR Project 8911

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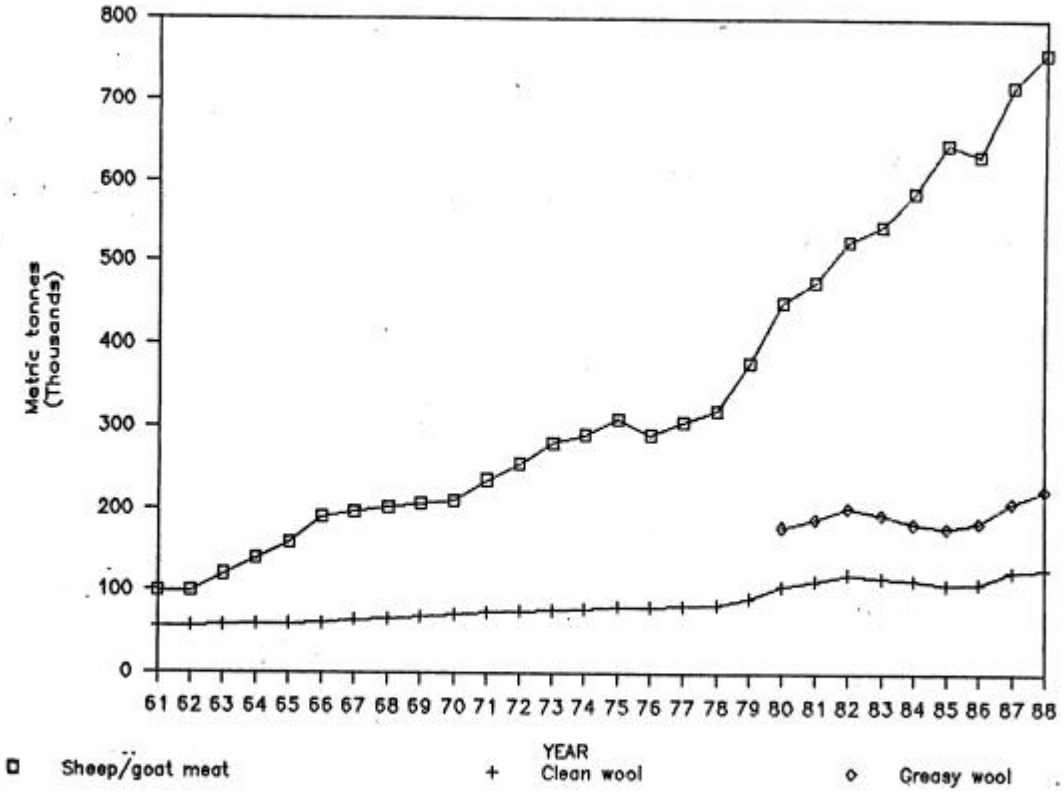
Area of concern to ACIAR Project 8911

Table 1. China wool and sheep/goat meat production ('000mt)

Commodity	Source	1961	1965	1970	1975	1980	1981	1982	1983	1984	1985	1986	1987	1988
Sheep/goat meat	1. China	100	160	210	309	450	475	525	545	586	646	632	722	759
	1. World	6,170	6,359	6,947	6,915	7,546	7,812	7,825	8,053	8,123	8,334	8,618	8,877	9,016
	% of World	1.6	2.5	3.0	4.5	6.0	6.1	6.7	6.8	7.2	7.8	7.3	8.0	8.4
Mutton	2.,3. China					444.8	476.1	523.9	544.7	585.8	N/A	N/A	719	N/A
	Kg/head					10.5	10.6	10.7	11.1	11.5	N/A	N/A	11.9	N/A
Wool (clean)	1. China	56	60	71	80	106	113	121	116	114	109	110	125	127
	1. World	1,490	1,571	1,684	1,562	1,654	1,689	1,732	1,746	1,756	1,800	2,988	3,042	3,124
	% of World	3.8	3.8	4.2	5.1	6.4	6.7	7.0	6.7	6.5	6.1	3.7	4.1	4.1
Wool (greasy)	1.,2.,3.					176	189	202	194	183	178	185	209	224
Fine 60-70						70	75	88	89	86	86	90	108	
Semi 46-58						37	39	42	38	34	32	33	37	
Coarse <46						70	75	72	67	63	60	62	64	
Total Sheep Numbers (millions)						106.63	109.47	106.57	98.92	95.19	94.21	99.00	102.66	
Raw wool yield	Kg/head					1.65	1.73	1.90	1.80	1.96	1.89	1.88	2.04	

Source:
1. FAO (1989)
2. Li Ze (1988)
3. China Agricultural Yearbook (1988)

Figure 2. Sheep/goat meat, wool production in China



Country	1901	1939	1969	1979	1984	1986	1987
				kg/head			
Australia	2.85	4.02	5.06	5.25	5.16	5.37	5.63
Argentina	2.67	3.79	4.64	4.86	5.40	5.96	
New Zealand	4.46	4.67	5.54	5.06	5.16	5.34	
South Africa	3.75	3.15	4.14	3.53	4.39	4.14	
Uruguay	2.69	3.17	3.78	3.66	3.89	4.08	
USSR	2.28	1.96	2.95	3.27	3.33	3.31	
China	n/a	1.26	1.34	1.49	1.96	1.88	2.04
WORLD	2.20	2.31	2.93	2.56	2.65	2.70	

Source: Copland (1987)
AIDAB (1987)

mineral supplements at numerous sites in five provinces. These provinces are Xinjiang and Gansu in the north-west and Inner Mongolia, Heilongjiang and Jilin in the north-east.

Fine and semi-fine woolled sheep in the five provinces account for 52% of all sheep in these provinces and 40% of all sheep nationally. The provincial and regional breakdown of fine wool, semi-fine wool and traditional coarse wool sheep is presented in Table 3.

Historically, the wool industry has been concentrated in the north-east and north-west regions of the country. These areas are becoming increasingly overstocked, with government pressure on farmers to reduce herd size. This also may have influenced the decline in sheep numbers.

Few sheep are located in the more fertile southern and central regions of China which have traditionally been devoted to food crops. These practices generally take precedence over animal husbandry where overcrowding and the need to be self sufficient in food production result in the inability of sheep farming to compete for valuable land. The use of the more fertile land for grain production is not simply an economic choice but an ideological decision, being an important component of the agricultural policy (Chey 1988). With sheep farming's requirement for better pasture land unlikely to be met in these more fertile areas where grain production for human consumption takes priority, the potential for expansion of sheep flocks into the more fertile southerly provinces is not likely to be realised (Chey 1988).

The main physical limiting factor in fine wool production is developing good pastureland. Climatic extremes and other priority land uses result in fine wool production being restricted to the existing overgrazed areas with expansion in output from an increase in sheep numbers unlikely. Other means to expand wool output need to be investigated such as correcting mineral deficiencies as being proposed by Project 8911.

The proportion of fine and semi-fine wool sheep in the national flock has been steadily increasing, most likely as a result of government policy in developing a domestic woollen textile industry. This has also been reflected in the proportion of the national wool clip produced by fine-woolled sheep. Total greasy wool production of all types from the five provinces was 123,337 mt in 1987 (see Table 4). This contributed 59% of the national wool clip. The five provinces are primarily fine and semi-fine wool producing areas with 77% of wool produced being of fine or semi-fine origin. The provincial breakdown of production is presented in Table 4.

Average fleece weights (greasy) for each wool type on a regional and national basis are also listed in Table 4. On average the fine and semi-fine wool sheep produced 3.36kg/head of greasy wool in 1987, above the national average of all wools of 2.04 kg/head. Based on the data in the table, the most favourable production areas appear to be those located in the north-east. The project has sites located in three of the eight north-east provinces.

Table 3. Distribution of fine and semi-fine wool sheep in China, 1987

Region/Province	Fine Wool	Semi-Fine Wool	Total Fine Semi-Fine Wool	Total Fine Semi-Fine Wool Fertile Ewes	Traditional	Total Sheep	Percentage of Fine Semi-Fine Wool in Province
	'000	'000	'000	'000	'000	'000	%
North-west							
Xinjiang	10,776	-	10,776	5,137	11,187	21,963	49.1
Gansu	1,534	840	2,374	1,116	5,911	8,285	28.7
Other	619	207	826	441	3,113	3,939	21.0
North-east							
Inner Mongolia	6,378	4,265	10,643	5,028	7,821	18,464	57.6
Heilongjiang	818	1,063	1,881	1,036	69	1,950	96.5
Jilin	1,208	236	1,444	854	12	1,456	99.2
Other	4,989	2,611	7,600	4,547	6,910	14,510	52.4
Other Regions	1,742	3,532	5,274	1,888	26,814	32,088	16.4
Five Provinces	20,714	6,404	27,118	13,171	25,000	52,118	52.0
TOTAL	28,064	12,754	40,818	20,047	61,837	102,655	39.8

Source: China Agricultural Yearbook 1988
Copland (1987)

Table 4. Greasy wool production and average fleece weights for selected provinces, 1987

Province	Total Raw Wool Prod'n mt	Average Fleece Weight kg/head	Fine Wool Prod'n mt	Average Fleece Weight kg/head	Semi-fine Wool Prod'n mt	Average Fleece Weight kg/head	Average Fleece Weight Fine & Semi-fine kg/head	Coarse Wool Prod'n mt	Average Fleece Weight kg/head
North west									
Xinjiang	44,597	2.03	35,678	3.31	-	-	3.31	8,919	0.80
Gansu	13,473	1.63	4,442	2.90	1,954	2.33	2.69	7,077	1.20
Other	6,798	1.73	2,126	3.43	413	2.00	3.07	4,259	1.37
North east									
Inner Mongolia	52,858	2.86	26,307	4.12	14,681	3.44	3.85	11,870	1.52
Heilongjiang	7,086	3.63	3,019	3.69	4,002	3.76	3.73	65	0.94
Jilin	5,323	3.66	4,413	3.65	874	3.70	3.66	36	3.00
Other	38,977	2.69	20,554	4.12	7,565	2.90	3.70	10,858	1.57
Other Provinces	39,796	1.24	3,519	2.02	7,552	2.14	2.10	28,725	1.07
Five Provinces	123,337	2.37	73,859	3.57	21,511	3.36	3.52	27,967	1.12
CHINA Total	208,908	2.04	100,058	3.57	37,041	2.90	3.36	71,809	1.16
Australia	916,000	5.63							

Source: China Agricultural Yearbook (1988)
AIDAB (1987)

wool pricing policy (AIDAB 1987). Mutton supply is market orientated whereas wool prices are set by the Central Government. Some flexibility in prices has occurred in recent years as indicated by the procurement prices of selected livestock products listed in Table 5. However, these prices are not necessarily based on economic values. Current prices are based on greasy weight and there is no standardised assessment system operating. Subjective assessment results in increased production costs as varying qualities are mixed and misused. Qualities such as fineness and clean yield have low priority as criteria used by buyers. Also, wool prices do not reflect adequately the greater costs involved in producing finer grades of wool. There is little incentive to class wool and adopt management practices that enhance wool quality. Table 6 indicates the low price differentials between wool qualities in 1985. Price differentials have shown a marginal improvement in 1987. Note the inconsistent classification systems between the two regions and subsequently, different prices for 'similar' wool lines.

A major area that requires attention is the wool marketing system. The whole process of price setting for inputs and outputs needs to be reviewed. Standardized classification systems need to be instigated for the efficient transmission of market signals to producers. Such reforms are essential to provide incentives for producers to adopt technology improving the quality and quantity of wool. Otherwise, research on the production aspects of wool have little input as they are unlikely to be adopted. These reforms are outside the scope of the project being considered but need to be kept in mind.

2.2 Regional Production of Mutton

Along with wool production, the north-east and north-west provinces dominate mutton production, accounting for 65% of slaughterings of sheep and goats in China. However, this share of slaughterings has been declining for these regions in recent years.

Table 7 shows national production of 719,000 mt disaggregated on a provincial basis. The north-east and north-west account for 66% of national production with the five provinces of concern contributing 36% of national output.

The north-east and north-west regions have on average a higher carcass weight to the rest of the nation. This would be primarily influenced by the ethnic population's preference for large-framed animals for meat production and to withstand the climatic extremes. Mutton production has a minor contribution to meat production in the southern regions (less than 1.5% in 1987) where pork production dominates. In the grazing regions, mutton has contributed up to 50% of meat production in some provinces but is still dominated by pork production in general (Tuan 1987).

Carcass weight for the mutton producing areas is generally higher than the national average, but still below countries such as Australia as listed in Table 7.

3. A BENEFIT-COST ANALYSIS OF PROJECT PROPOSAL 8911

3.1 Assumptions

Based on information provided in the project proposal, presented in previous tables and from experimental results of previous ACIAR projects, certain assumptions about adoption, price

Table 5. Procurement prices of selected livestock products, China

Year	Wool Greasy kg	Sheep Meat	Sheep skins	Official Exchange Rate		
	Yuan/kg	Y/hd	Y/piece	Y/US$	Y/A$	US/A
1971	3.00	13.3				
1972	3.00	13.3				
1973	2.88	14.2				
1974	3.06	15.2				
1975	3.06	14.0	3.7			
1976	3.12	13.5				
1977	3.28	13.5				
1978	3.40	14.7	4.2			1.128
1979	3.40	17.7	4.5			1.131
1980	3.43	21.7	4.5	1.49		1.114
1981	3.48	25.6	4.7	1.70		1.161
1982	3.58	26.0	4.7	1.89		1.0174
1983	3.66	27.8	4.7	1.88		0.9025
1984	3.73	29.0	5.3	2.32		0.8796
1985	5.04	39.1	9.4	2.94		0.7008
1986				3.45		0.6709
1987	6.2-9.0			3.7	2.76	0.7009
1988	7.0			3.7		
1989					3.55	
1990						1.59

Source: Tuan (1987)
AIDAB (1987)
Copland (1987)
Martin (1988)

Table 6. Price differentials for varying wool grades

Region	Grade	Bradford Court	Micron Fibre Diameter	1985 Yuan/kg*	1987 Yuan/kg
Inner Mongolia	Superior	70s	18-21	2.75	7.20
	First	64s	21-23	2.50	6.56
	Second	60s	234	2.34	6.20
Xinjiang	Superior	64s	18-23	2.75	9.0
	First	64s		2.75	7.7
	Second	64s		2.34	6.3

* Conversion Rate $A1 = 2.76 Yuan (1987)

Source: AIDAB (1987)

Table 7. Mutton production and average carcass weight for selected provinces, 1987

Province	Mutton Production ('000 mt)	Number Slaughtered ('000 head)	Average Carcass Weight kg/head
North West			
Xinjiang	122	8,202	14.87
Gansu	31	2,079	14.91
Other	25	1,767	14.15
North East			
Inner Mongolia	95	7,177	13.24
Heilongjiang	6	415	14.46
Jilin	5	415	12.05
Other	194	19,426	9.99
Other Provinces	241	21,045	11.45
CHINA Total	719	60,529	11.88
Australia - Mutton	293	14,950	19.60
- Lamb	293	17,188	17.05

Source: China Agriculture Yearbook (1988)
ABARE (1989)

and production increases will be discussed. A sensitivity analysis will also be included.

3.1.1 Ceiling Rate of adoption, Adoption Lag

The analysis assumes that 80% of farmers will adopt the mineral supplement technology. The ceiling rate of adoption will peak in Year 15, with the first farmers adopting the technology in Year 5. Sensitivity analyses are done on the project for a 50% and 30% level of adoption. Adoption is assumed to follow a sigmoid curve.

3.1.2 Sheep Numbers and Phasing

The research is assumed to influence only the fine wool and semi-fine wool sheep of the regions in the north-east and north-west that have experimental test sites. These regions are listed in Section 2 and account for 67% of all fine/semi-fine wool sheep in China (see Table 3). The project area has over 27 million fine wool and semi-fine wool sheep, of which 21.7 million or 80% are assumed to be supplementing their diet with mineral licks in Year 15. The phasing of sheep numbers adopting the technology in each year is set out in Table 8.

3.1.3 Price

(i) Wool Price

The price used for wool is the procurement price for 1987 as other information is also available for this year even though more recent price data is available. Table 6 highlights the range of prices depending on quality. The price used has been 6.2 Yuan/kg greasy (or $A2.25 kg/greasy). The lowest level of quality has been assumed though this may not necessarily be the case. Until more detailed data is provided, the more pessimistic estimate is used. The research may improve production and quality which could be reflected in better prices for the higher quality wool which will be produced in greater quantities. Until the marketing and incentive system improves to warrant adoption of better techniques to improve quality and handling through an adequate price mechanism, the lower price is assumed. The price quoted in the project proposal ($A10/kg clean) is somewhat high. Firstly, China's wool price is quoted on a greasy basis, with low wool yields (40-45%). Secondly, even in Australia $A10 kg is well above the floor price and current world price. Finally, even in a free and improved market in China, wool prices may rise 25%-40% above the fixed procurement price (AIDAB 1987). With domestic demand for wool greater than domestic supply, prices could also rise but the extent of these changes is uncertain. Until further research and reform of the marketing system for wool is undertaken, the current situation is taken as given and a price of 6.2 Yuan/kg greasy is assumed.

(ii) Mutton Price

A mutton price of Y39.1/head is assumed in the analysis. The price for mutton is more market orientated than wool as indicated by the price series in Table 5. The procurement price converts to $A10.51/head at the exchange rate of Y2.76/$A.

3.1.4 Production Effects of Mineral Supplement Research

Production increases from the use of supplements are reflected in sheep wool and meat

Table 8. Adoption of technology - phasing of fine and semi-fine wool sheep numbers ('000), 1987

Province	Total Fine/ Semi/Fine Sheep	Year 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15-30
Adoption rate		0	0	0	0	0.007	0.020	0.073	0.113	0.167	0.233	0.340	0.553	0.700	0.760	0.800
Xinjiang	10,776	0	0	0	0	75	216	787	1,218	1,800	2,511	3,664	5,959	7,543	8,190	8,621
Gansu	2,374	0	0	0	0	17	47	173	268	396	553	807	1,313	1,662	1,804	1,899
Inner Mongolia	10,643	0	0	0	0	75	213	777	1,203	1,777	2,480	3,619	5,886	7,450	8,089	8,514
Heilongjiang	1,881	0	0	0	0	13	38	137	213	314	438	640	1,040	1,317	1,430	1,505
Jilin	1,444	0	0	0	0	10	29	105	163	241	336	491	799	1,011	1,097	1,155
Total	27,118	0	0	0	0	190	542	1,980	3,064	4,529	6,318	9,220	14,996	18,983	20,610	21,694

Total Fine/Semi-fine wool sheep : China ('000) 40,818
: Five Provinces 27,118

Source: China Agricultural Yearbook (1988)

production through increased body weight, improved lambing and increased wool growth.

(i) Wool

The project proposal cites a response in wool growth of 200 grams of greasy per head from results of a previous project (PN 8454). At a yield of 45%, this converts to an increase of 90 grams clean wool per sheep. Another experiment mentioned in the project (source unknown) indicates a response of 120 grams/head of clean wool to copper and selenium treatments. This converts to 267 grams/head increase in greasy wool fleece weight. With raw wool yield per head averaging 3.2 kg for fine and semi-fine wool sheep, an increase of 200-267 gms/hd greasy wool represents a 6-8% increase in average fleece weight. It should be noted that these results are experimental and the full effect may not necessarily be translated to the field. It is expected that the analysis will be very sensitive to the level of wool growth in response to mineral supplements. Initially, the analysis will assume an increase in greasy fleece weight per sheep of 267 grams.

(ii) Mutton

It has been estimated from previous projects that there is a 4% increase in the number of lambs weaned. It is assumed that the increase in weaning translates into a 4% increase in slaughterings. The improved nutritional status of the sheep improves body weight conditions in ewes which translate to a more successful reproductive cycle. The improved lambing and weaning can be seen in increased slaughterings.

To estimate the increase in sheep for slaughter, the number of fertile fine/semi-fine wool ewes adopting the technology for a given year is multiplied by the 4% increase in weaning rate. This represents the extra animals available for slaughter each year. Each extra slaughtered sheep is valued at $10.51 head. Table 9 tabulates the fertile ewes available each year.

The final increase in sheep production is equivalent to approximately 5900 mt of extra mutton production per year. This represents an increase in mutton production of 1% for the five provinces, and 0.8% nationally.

3.1.5 Costs

The total costs of adding mineral supplements to the existing salt licks is assumed to be $A0.72 per head. As animal salt licks are already available, a production and distribution system is already established. The costs therefore only include the cost of raw materials (ie trace minerals) and the cost of adding the supplements to the licks. Other procedures are already established and therefore built into the existing cost of production.

3.1.6 Research Costs

The costs of research to all organizations and collaborating institutions are included. These are specified in more detail in the project documents.

3.2 Results of the Analysis

A detailed analysis could be developed using the methodology developed by Davis et al.

Table 9. Adoption of technology - fertile ewes available ('000), 1987

Province	Total Fine/ Semi-Fine Fertile Ewes ('000)	Year 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15-30
Adoption Rate		0	0	0	0	0.007	0.020	0.073	0.113	0.167	0.233	0.340	0.553	0.700	0.760	0.800
Xinjiang	5,137	0	0	0	0	36	103	375	580	858	1,197	1,747	2,841	3,596	3,904	4,110
Gansu	1,116	0	0	0	0	8	22	81	126	186	260	379	617	781	848	893
Inner Mongolia	5,028	0	0	0	0	35	101	367	568	840	1,172	1,710	2,780	3,520	3,821	4,022
Heilongjiang	1,036	0	0	0	0	7	21	76	117	173	241	352	573	725	787	829
Jilin	854	0	0	0	0	6	17	62	97	143	199	290	472	598	649	683
Total Fertile Ewes	13,171	0	0	0	0	92	263	961	1,488	2,200	3,069	4,478	7,284	9,220	10,010	10,537

Total Fine/Semi-fine wool sheep : China ('000) 40,818
: Five Provinces 27,118

Source: China Agricultural Yearbook (1988)

(1987) for research priority assessment work. However, a simplified spreadsheet approach has been used as the potential overestimation is considered small. It is assumed the domestic supply of fine/semi-fine wool is relatively inelastic due to factors such as climates and marketing, severely restricting expansion by a limit on area and sheep numbers. Domestic demand is considered to be more elastic, being partially driven by export markets. Domestic demand by processors exceeds supply. The shortfall is partially filled by imports but excess mill capacity still exists.

The spreadsheet analysis assumes domestic demand is perfectly elastic. Any production increases do not affect farm gate price which is administratively fixed and not subject to direct market forces. Through assuming a totally elastic domestic demand and relatively inelastic supply all benefits of research through production increases are appropriated by wool and meat producers.

The spreadsheet analysis of the project under the previously discussed assumptions results in an Internal Rate of Return (IRR) of 32.4%. The project generates a net present value of benefits (NPV) totalling $5.4 million, using a 10% discount rate. The cash flow analysis of undiscounted values is presented in Table 10.

A delay in initiating adoption of the technology results in the IRR falling. With a lag of 7 years (or 3 years after the completion of research) and the maximum ceiling level of adoption reached in Year 17, the IRR falls to 26.9%.

The effect of lowering the ceiling level of adoption to 50% and 30% from the current level of 80% was measured. For a ceiling adoption level of 50% in year 15, the IRR fell 17% to 27%. The NPV of the project declined 43% to $3.1 million. The IRR for a 30% ceiling adoption level was 21.4% which is a 34% decline from the 80% adoption level. The NPV more than halves to $1.6 million. It is therefore important to ensure the highest possible level of adoption. Appendix 1 contains a sensitivity analysis which was conducted under two scenarios.

(i) Wool production increases and price per kilogram of greasy wool were varied while mutton price and production increase were held constant at $10.51 and 4% respectively;

(ii) Mutton production increases through variation of increases in the weaning rate and mutton prices per head were varied while wool production increases and price remained constant at 267 gr/head of greasy wool and $2.25 kg of greasy wool.

The results are presented in Table 11 and Table 12 which are graphed in Figure 3 and Figure 4. Internal Rates of Return changes are recorded on the vertical axis against production changes on the horizontal axis for varying price levels. (Price was held constant for each separate line since price variation was considered less volatile since procurement prices are set administratively and not due to direct market prices.)

The resulting curves for both wool and mutton variations show relatively flat curves for higher production changes. However, IRRs dramatically fall and become negative if production increases are not greater than 2-3%.

Table 10. Benefit-cost analysis of ACIAR Project 8911

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20 -∞
Sheep Numbers																				
Xinjiang	0	0	0	0	75432	215520	786648	1217688	1799592	2510808	3663840	5959128	7543200	8189760	8620800	8620800	8620800	8620800	8620800	8620800
Gansu	0	0	0	0	18618	47480	173302	268262	396458	553142	807160	1312822	1661800	1804240	1899200	1899200	1899200	1899200	1899200	1899200
Inner Mongolia	0	0	0	0	74501	212860	776939	1202659	1777381	2479819	3618620	5885579	7450100	8088680	8514400	8514400	8514400	8514400	8514400	8514400
Heilongiang	0	0	0	0	13167	37620	137313	212553	314127	438273	639540	1040193	1316700	1429560	1504800	1504800	1504800	1504800	1504800	1504800
Jilin	0	0	0	0	10108	28880	105412	163172	241148	336452	490960	798532	1010800	1097440	1155200	1155200	1155200	1155200	1155200	1155200
Phasing (Sheep no.'s)	0	0	0	0	189826	542360	1979614	3064334	4528706	6318494	9220120	14996254	18982600	20609680	21694400	21694400	21694400	21694400	21694400	21694400
Fertile Ewes	0	0	0	0	92197	263420	961483	1488323	2199557	3068843	4478140	7283563	9219700	10009960	10536800	10536800	10536800	10536800	10536800	10536800
Benefits																				
Wool	0	0	0	0	113854	325298	1187338	1837934	2716238	3789721	5530086	8994489	11385429	12361323	13011919	13011919	13011919	13011919	13011919	13011919
Sheep meat	0	0	0	0	38760	110742	404207	625691	924694	1290142	1882610	3062010	3875982	4208187	4429671	4429671	4429671	4429671	4429671	4429671
	0	0	0	0	152614	436040	1591545	2463825	3640932	5079863	7412676	12056499	15261391	16569510	17441590	17441590	17441590	17441590	17441590	17441590
Costs																				
Mineral Supplement @ $0.72/sheep	0	0	0	0	136675	390499	1425322	2206320	3260668	4549316	6638486	10797303	13667472	14838970	15619968	15619968	15619968	15619968	15619968	15619968
Benefits-Costs	0	0	0	0	15939	45541	166223	257304	380264	530547	774189	1259196	1593919	1730541	1821622	1821622	1821622	1821622	1821622	1821622
Research Costs																				
ACIAR	188660	160530	103570																	
CSIRO	47500	47500	47500																	
Beijing IAS	18100	12400	12400																	
	254260	220430	163470																	
NET BENEFITS	-254260	-220430	-163470	0	15939	45541	166223	257304	380264	530547	774189	1259196	1593919	1730541	1821622	1821622	1821622	1821622	1821622	1821622
IRR	32.4																			
NPV	5413547																			

Table 11. Sensitivity analysis of wool to changes in price and output increases[1]

Increase in Greasy Wool per Sheep	Price/kg Greasy					
	$/kg					
Grams/Head	1.75	2.00	2.25	2.50	3.00	4.00
	IRR%					
300	11.4	32.5	40.7	46.4	54.5	65.2
275		22.6	34.9	41.8	50.8	62.1
267		16.8	32.6	40.1	49.5	61.0
250			25.8	35.7	46.4	58.6
240			22.0	32.4	44.3	57.0
235			11.8	30.5	43.2	56.2
232			3.9	29.3	42.5	55.7
200					32.4	49.4
150						32.4

[1] Mutton output and price held constant at 4% increase fixed in slaughterings and $10.51 head respectively

Table 12. Sensitivity analysis of mutton to changes in price and output increases[1]

Increase in Weaning Rate	Price/Head						
	$/Head						
	9.0	9.5	10.0	10.51	11.0	11.5	14.0
%	IRR%						
7	42.9	44.2	45.4	46.6	47.6	48.7	53.2
6	39.2	40.5	41.8	43.0	44.1	45.1	49.6
5	34.4	35.8	37.2	38.5	39.6	40.7	45.4
4	27.5	29.3	30.9	32.4	33.7	35.0	40.1
3	12.7	16.9	19.8	22.3	24.2	25.9	32.4
2.8	2.1	11.2	15.6	18.8	21.2	23.2	30.3
2.7		6.3	12.7	16.6	19.3	21.6	29.1
2.6			8.5	13.8	17.1	19.7	27.9
2.5			-1.1	9.8	14.3	17.4	26.5
2.4				2.4	10.4	14.6	24.9
2.3					3.2	10.6	23.2
2.2						3.2	21.2
2.1							18.7
2.0							15.6

[1] Wool output and price held constant at 267 gram increase in raw wool production at a price of $2.25 kg.

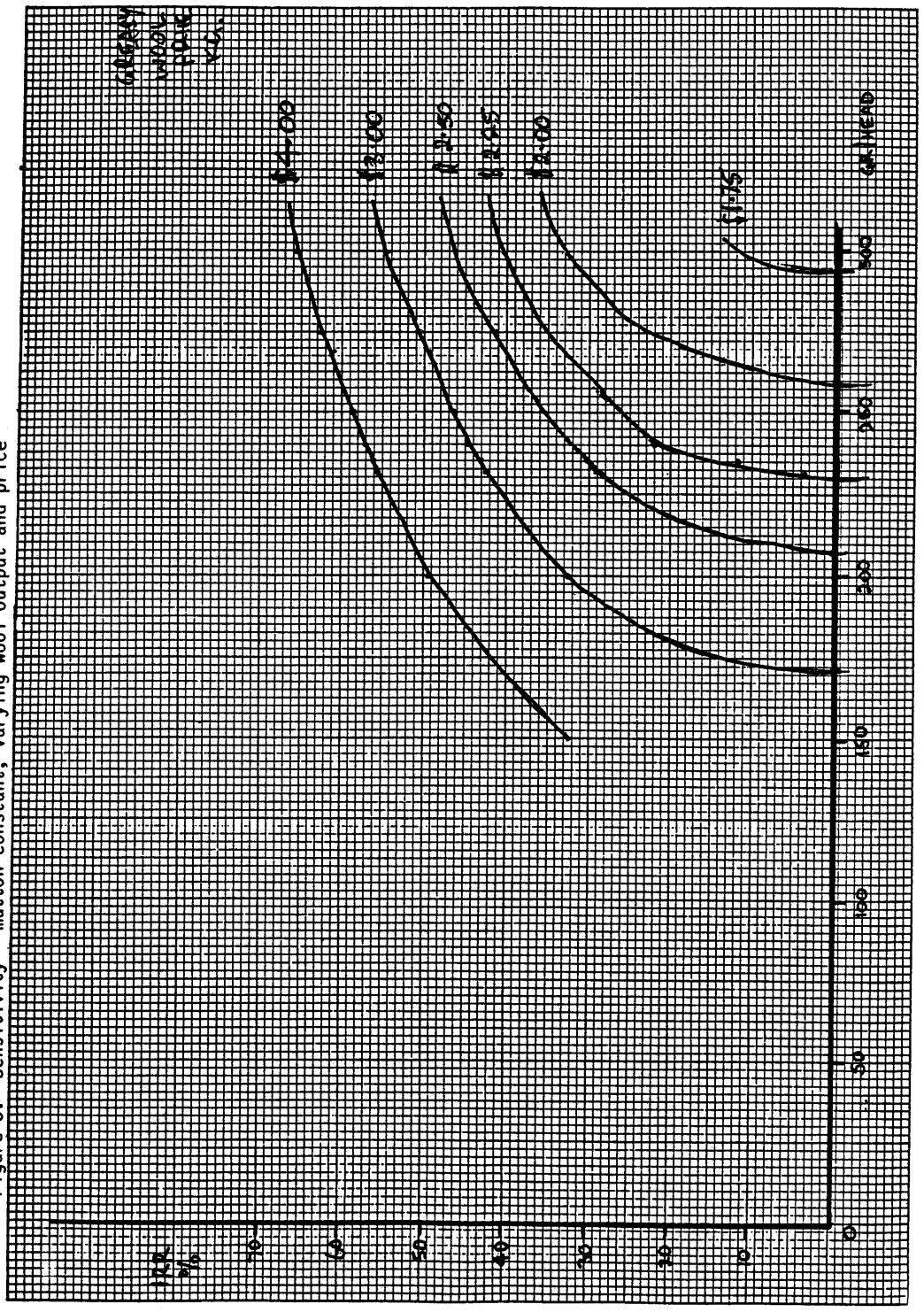


Figure 3. Sensitivity - mutton constant, varying wool output and price

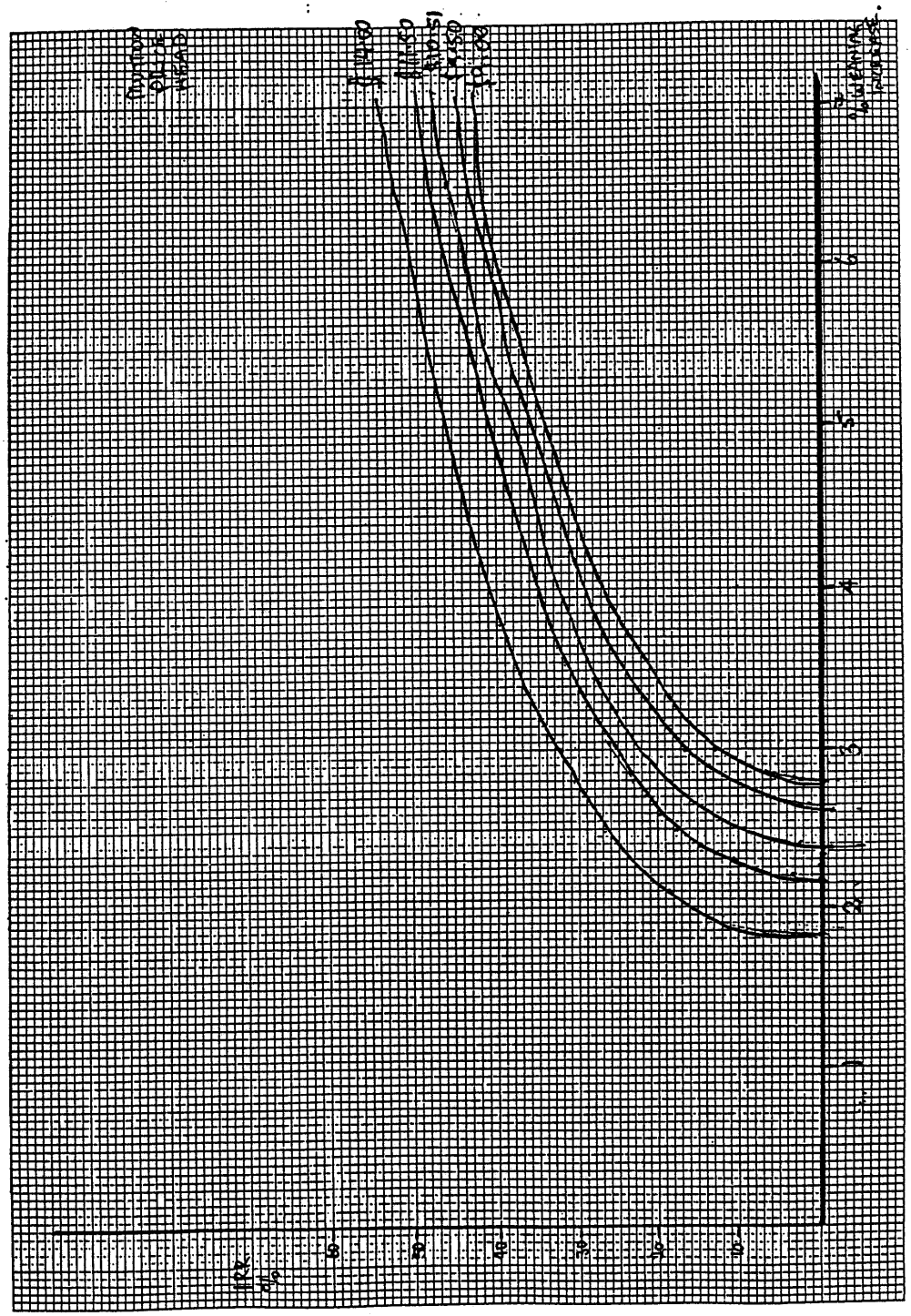


Figure 4. Wool constant, varying mutton, price and output

Both wool and mutton appear extremely sensitive to production variations unless prices are much higher than current levels. If the research is to be successfully adopted and provide an adequate return, it is extremely important that sufficient incentives are provided to producers in the form of superior prices and improved market infrastructure to cope with improving quality, and that quality improvements are translated into price signals that producers are willing to respond to.

The project under its current assumptions falls into the acceptable range for agricultural projects, yet the sensitivity to changes in the level of production should be noted.

A production or price fall can be suffered in either commodity and the project can still show a favourable IRR. However, in the worst case scenarios where prices of both commodities fall by 7-11%, or production target increases are not reached (min. 3.4% increase for mutton and 244 grams increase for wool) then the project's IRR falls below zero.

Under current assumptions the project appears favourable. The current assumption can be considered conservative and is open for review. Under such conservative estimates, the project still produces a favourable IRR. Even though outside the scope of the project, other constraints will potentially have an influence on the actual outcome of the project (ie climatic) as well as the successful adoption of the technology (economic and marketing systems). These other areas need to be considered when assessing the final impact of the project.

APPENDIX

Table A1. Benefit-cost analysis of ACIAR Project 8911

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20-30
Sheep Numbers																				
Xinjiang	0	0	0	0	140088	290952	506472	721992	1002168	1433208	2155200	3308232	4450488	5172480	5388000	5388000	5388000	5388000	5388000	5388000
Gansu	0	0	0	0	30862	64098	111578	159058	220782	315742	474800	728818	980462	1139520	1187000	1187000	1187000	1187000	1187000	1187000
Inner Mongolia	0	0	0	0	138359	287361	500221	713081	989799	1415519	2128600	3267401	4395559	5108640	5321500	5321500	5321500	5321500	5321500	5321500
Heilongjiang	0	0	0	0	24453	50787	88407	126027	174933	250173	376200	577467	776853	902880	940500	940500	940500	940500	940500	940500
Jilin	0	0	0	0	18772	38988	67868	96748	134292	192052	288800	443308	596372	693120	722000	722000	722000	722000	722000	722000
Phasing (Sheep no.'s)	0	0	0	0	352534	732186	1274546	1816906	2521974	3606694	5423600	8325226	11199734	13016640	13559000	13559000	13559000	13559000	13559000	13559000
Fertile Ewes	0	0	0	0	171223	355617	619037	882457	1224903	1751743	2634200	4043497	5439623	6322080	6585500	6585500	6585500	6585500	6585500	6585500
Benefits																				
Wool	0	0	0	0	211444	439152	764450	1089748	1512636	2163232	3252980	4993324	6717403	7807151	8132449	8132449	8132449	8132449	8132449	8132449
Sheep meat	0	0	0	0	71982	149501	260243	370985	514949	736433	1107418	1699886	2286818	2657802	2768544	2768544	2768544	2768544	2768544	2768544
	0	0	0	0	283426	588654	1024693	1460733	2027585	2899664	4360397	6693210	9004221	10464954	10900994	10900994	10900994	10900994	10900994	10900994
Costs																				
Mineral Supplement @ $0.72/sheep	0	0	0	0	253824	527174	917673	1308172	1815821	2596820	3904992	5994163	8063808	9371981	9762480	9762480	9762480	9762480	9762480	9762480
Benefits-Costs	0	0	0	0	29601	61480	107020	152561	211764	302845	455405	699047	940412	1092973	1138514	1138514	1138514	1138514	1138514	1138514
Research Costs																				
ACIAR	188660	160530	103570																	
CSIRO	47500	47500	47500																	
Beijing IAS	18100	12400	12400																	
	254260	220430	163470																	
NET BENEFITS	-254260	-220430	-163470	0	29601	61480	107020	152561	211764	302845	455405	699047	940412	1092973	1138514	1138514	1138514	1138514	1138514	1138514
IRR	27.0																			
NPV	3137774																			

Table A2. Benefit-cost analysis of ACIAR Project 8911

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20-70
Sheep Numbers																				
Xinjiang	0	0	0	0	75432	140088	215520	290952	506472	862080	1293120	1939680	2726328	3157368	3232800	3232800	3232800	3232800	3232800	3232800
Gansu	0	0	0	0	16618	30862	47480	64098	111578	189920	284880	427320	600622	695582	712200	712200	712200	712200	712200	712200
Inner Mongolia	0	0	0	0	74501	138359	212860	287361	500221	851440	1277160	1915740	2692679	3118399	3192900	3192900	3192900	3192900	3192900	3192900
Heilongjiang	0	0	0	0	13167	24453	37620	50787	88407	150480	225720	338580	475893	551133	564300	564300	564300	564300	564300	564300
Jilin	0	0	0	0	10108	18772	28880	38988	67868	115520	173280	259920	365332	423092	433200	433200	433200	433200	433200	433200
Phasing (Sheep no.'s)	0	0	0	0	189826	352534	542360	732186	1274546	2169440	3254160	4881240	6860854	7945574	8135400	8135400	8135400	8135400	8135400	8135400
Fertile Ewes	0	0	0	0	92197	171223	263420	355617	619037	1053680	1580520	2370780	3332263	3859103	3951300	3951300	3951300	3951300	3951300	3951300
Benefits																				
Wool	0	0	0	0	113854	211444	325298	439152	764450	1301192	1951788	2927682	4115019	4765615	4879470	4879470	4879470	4879470	4879470	4879470
Sheep meat	0	0	0	0	38760	71982	110742	149501	260243	442967	664451	996676	1400883	1622367	1661127	1661127	1661127	1661127	1661127	1661127
	0	0	0	0	152614	283426	436040	588654	1024693	1744159	2616238	3924358	5515903	6387982	6540596	6540596	6540596	6540596	6540596	6540596
Costs																				
Mineral Supplement @ $0.72/sheep	0	0	0	0	136675	253824	390499	527174	917673	1561997	2342995	3514493	4939815	5720813	5857488	5857488	5857488	5857488	5857488	5857488
Benefits-Costs	0	0	0	0	15939	29601	45541	61480	107020	182162	273243	409865	576088	667169	683108	683108	683108	683108	683108	683108
Research Costs																				
ACIAR	188660	160530	103570																	
CSIRO	47500	47500	47500																	
Beijing IAS	18100	12400	12400																	
	254260	220430	163470																	
NET BENEFITS	-254260	-220430	-163470	0	15939	29601	45541	61480	107020	182162	273243	409865	576088	667169	683108	683108	683108	683108	683108	683108
IRR	21.4																			
NPV	1634421																			

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