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Improvement of Small Ruminant Production Systems in Rainfed Agro-Ecological Zones of Asia

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Abstract: Small ruminants (goats and sheep) form an important economic and ecological niche in Asian mixed farming systems. This is reflected in their wide distribution across ecosystems, value as genetic resources, productivity and significance of ownership. Approximately 60% of the 674 million goats and 20% of the 1048 million sheep are found in Asia. India, China, Pakistan and Bangladesh account for about 84%, and China, India and Pakistan, 72% of the total populations of goats and sheep, respectively in Asia. They are concentrated mainly in rainfed semi-arid and arid, and sub-humid and humid lowland and upland areas in mixed farm situations, where about 83% of the total small ruminant populations can be found. Their ownership, especially by poor people, is associated with several objectives to meet short-term socio-economic needs, security and survival in which these species enable diversification of resources to reduce risks, alleviation of poverty, promotion of linkages between system components, and stability of farm households. Prevailing small ruminant production systems are described. The opportunities for research are considerable and are indicated. The strategy for increasing their contribution involves more attention to the rainfed lowland and upland areas, more efficient use of the available breeds, targeting the poor to address poverty, and wider use of improved technologies through community-based participation that address both improved production and post-production systems.

Key words: Ruminants, goats, sheep, farming systems, indigenous breeds, nomadism, transhumance, land use.

Small ruminants (goats and sheep) form an important economic and ecological niche in Asian mixed farming systems. This is reflected in their wide adaptation, wide distribution across ecosystems, varied functions and socio-economic contribution. In Asia, both species are found in the high Himalayas, in the semi-arid and arid areas of Pakistan, India and Mongolia, as well as in the high rainfall and high humidity South East Asian region, including Mekong countries.

Associated with their wide distribution across various ecosystems, they produce food, fiber and skins, and also make a significant contribution to human nutrition, total farm income and the stability of farming systems. Concerned with the latter, is the association with poor people for whom there are important benefits that are linked

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to food security, survival and sustainable livelihoods.

The purpose of this paper is to highlight the value and economic importance of both species in prevailing production systems, and opportunities for increasing the contribution in the future.

Value of Small Ruminants

Goats and sheep are valued for a variety of important contributions. Thus, farmers raise them with several objectives to meet the socio-economic, cultural and recreational needs. Small size is especially significant as it relates directly to economic, managerial and biological advantages. This is associated in turn with the following benefits (Devendra, 1989; Devendra and Burns, 1989):

- income: important means of earning supplementary income:
- food: provide animal proteins (milk and meat) for the nutritional well-being of peasants and especially the undernourished;
- security: source of investment, security and stability;
- employment: creation of employment, including effective utilization of unpaid family labor;
- fertiliser: contribution to crop production, and farm fertility through the return of dung and urine;
- by-product utilization: they enable economic utilization of non-marketable crop residues to generate value-added products, e.g., meat, fiber and skins;
- social values: ownership has been shown to increase cohesiveness in village activities and religious ceremonies;
- recreation: socio-economic impact of animal ownership also includes a recreational contribution to small farmers.

With specific reference to goats, detailed socio-economic surveys on 900 farm families in Rajasthan, to study the relationship between types of goat keeping families, size of land holdings and ownership of other ruminants, indicated that the highest population of 44% of the farmers (less than $ 24 per caput a year) with no land were the owners of goats, followed by 32% farmers having 0.2-0.4 ha land, and a smaller number of 25% of the farmers having 0.7 to more than 2 ha land (Rangnekar, personal communication). In the Mymensingh district of Bangladesh, long-term detailed socio-economic surveys indicated that the poor farmers who represented 30% of the households and had 0-0.5 ha of land, owned the largest number (44%) of goats. The farmers with more than 2 ha of land tended to own a large proportion of cows and bullocks (57%).

The various benefits, together with their small size, enable farming families to spread risks through diversification. These risks, especially environmental, are much greater in the more marginal and rangeland areas where rainfall and available feeds are sparse, typical of the arid and semi-arid tropics. Since both species are heavily concentrated in these same areas, their effective use here becomes especially important. Additionally, small ruminants in these marginal areas provide the main, if not the only, means of livelihood, combining economic

and food security, nutrition and means of survival. In these circumstances, the importance of both species, especially to the very poor and landless peasants, increases with decreasing quality of grazing and feed availability in harsh environments.

The Poverty Scenario

It is important to keep in perspective the importance of the ownership of small ruminants by very poor people. The link between small ruminants and very poor people is the poverty focus. In South Asia and Sub-Saharan Africa, between 48-49% of the population, represented by the head-count index, is below the poverty line. The incidence of poverty is highest in rural areas, which for India and Indonesia in Asia for example, is about 79-91%, and for Co'te d'Ivorie, Ghana and Kenya in Africa between 80 and 96% (World Bank, 1990). About 49% of the poor population in South Asia live below the poverty line (World Bank, 1993). The poverty dimension concerns mainly small farmers, the landless pastoralists, transhumants, women, indigenous tribal groups and displaced persons. A very large proportion of these individuals are associated with goats, which not only provide a means of survival and security, but also in the supply of precious dietary animal proteins and also cash income. Being fragile and vulnerable, these groups merit special attention and policy support in the context of poverty alleviation, and the role and contribution of goats is an important means to achieve this objective.

Some characteristics of very poor people and rural poverty are: they are low-income individuals, usually crop-oriented but often own goats and sheep; have none or very limited access to resources, especially land, which, if available, is fragile and marginal, or may be landless; are involved in a variety of income generating activities; face geographic isolation; continuously experience hunger, fight for survival, but can adapt to hardship; resist change and are unable to use new technology; are sensitive to risk and reduce this by diversification of the meagre resources; majority are not interested in prescriptions and extension materials; and provide core family labour, including women and children, to herd goats and sheep. The key elements in all the available descriptions, definitions of poor people and the poverty focus are survival, subsistence, low income and illiteracy (Devendra, 1992).

Targeting Poverty and the Poor

The alleviation of poverty, improved livelihoods of the poor and food security are national objectives in most countries. Targeting the poor is therefore an important development strategy, because particularly in harsh environments, potential improvements are associated with a complex web of interactions between poverty, population dynamics, agricultural growth and survival. The latter is of no significance to poor people, whose main objective is subsistence living and who perceive that inefficient use of natural resources and environmental degradation are unimportant, if their immediate needs and short-term survival are not assured. Development strategies must, therefore, target the poor as direct beneficiaries in which integrated natural resource management and use, inter-disciplinarity and community-based participatory approaches are addressed.

Table 1. Goat and sheep populations in developing countries of Asia

Species	Population	Percentage of world population	Annual rate of growth (1990-96, %)
Goats	58.0	53.1	3.5
Sheep	217.1	20.7	0.7

The association of small ruminants with the poor and opportunities for improving productivity in them provides an additional, and further impetus to increase resource use for increasing the contribution from both species. The direct benefits to this intervention are likely to have a major impact on potential productivity from goats and sheep, assisting the poor and protecting the environment.

Small Ruminant Resources

Size

Table 1 presents the size of the goat and sheep populations in Asia. The size of individual populations is considerable, with goats and sheep accounting for 53.1% and 20.7% of the total world population and 30.2% and 22.7% as percentage of total grazing ruminants (buffalo, cattle, goats and sheep) in Asia, respectively. Some specific features within species are as follows:

Goats: The largest populations were found in India (35.2%), China (29.3%), Pakistan (12.0%), and Bangladesh (7.8%). These countries together accounted for about 84% of the total population of goats in Asia. The ratio of sheep to goats is 1:1.3. The FAO Data Bank for Global Animal Genetic Resources indicates that there exist 146 breeds.

Sheep: The largest populations are found in China (43.7%), India (17.8%), Pakistan (11.0%) and Mongolia (5.8%). China, India and Pakistan together accounted for about 72% of the total population of sheep in Asia. There exists an estimated 231 breeds of sheep.

Although the number of sheep breeds is higher than that of goats, this is due to the many exotic breeds of sheep that have been used, including their crossbreeds in Asia. In respect of goats, the number

Table 2. Relative size of cattle and small ruminant (goats and sheep) populations (millions) in the lowland and upland areas of Asia (CGIAR Technical Advisory Committee, 1992)

Ecoregion	Cattle	Small ruminants (Goats & Sheep)
Rainfed: arid and semi-arid tropics & sub-tropics	179	221
Rainfed humid/sub-humid tropics & sub-tropics	186	265
Total (millions)	365	486
Percentage of total population in Asia	96.8	83.0

Table 3. Number of goat and sheep breeds recorded in the FAO Global Databank

Species	Number of breeds			Risk (%)
	Recorded	With population size data	At risk*	
Goat				
Global	351	207	44	16.5
Asia	126	96	6	6.3
Sheep				
Global	920	656	119	18.1
Asia	226	155	15	9.7

*Estimated from breeds with available population data.

of breeds is a good reflection of the number of indigenous breeds present.

Corresponding to the relative population of goats and sheep, the volume of goat meat produced is higher than that of sheep. Current levels of goat meat, and mutton and lamb production are 64.0% and 22.6% of the total world output, respectively. It is pertinent to note that all these meats produced are used for domestic consumption within countries and productivity of both species has not as yet become affected by regional trade.

Data on the distribution of goat populations within the various ecosystems (lowland irrigated, rainfed lowland, uplands and highlands) in Asia is limited. However, Table 2 provides some useful information. The data for goats is mixed with that of sheep, but Table 1 gives the magnitude and relative concentrations of cattle and small ruminants in the rainfed lowland and upland areas. Between species, the small ruminant populations were higher than that of cattle. Additionally, the size of the individual populations was large, and accounted for as much as 96.8% and 83.0% of the total populations of cattle and small ruminants, respectively, in Asia.

Indigenous breeds

Of particular significance is the presence of a variety of breeds that are useful for meat, milk, fiber and skins. Out of a world total of 351 goat breeds, Asia has about 146 of these indigenous breeds, and 59 others are found in Africa. Table 2 gives an indication of the total number of goat breeds available globally in comparison with sheep for Asia, listed in the FAO data bank. Asia accounts for 36% of all goat breeds and 25% of all sheep breeds. At the global level, 16.5% of the goat breeds and 18.1% of the sheep breeds are considered to be at risk. Breed improvement has generally failed to focus on their selection and increased per animal performance mainly because of neglect and inadequate resource use. Consequently, there is genetic erosion and a generally low level of production. In the absence of objective evaluation, productive performance and practical difficulties involving all breeds, characterisation of the genetic diversity within and between breeds, and determination of the genetic relationships has been suggested (Barker, 1996). It is important to draw attention to the presence of several potentially important "improved

breeds". In the absence of more concentrated and wider use of these, the potential productivity from goats remains to be achieved. Unlike indigenous sheep, many of these breeds have been introduced into other countries to improve the productivity of indigenous goats. These include, Jamnapari, Barbari and Black Bengal, Malabar and Kashmiri in India; Ma'tou in China; Zaraiby in Egypt; Black Bedouin in Israel; West African Dwarf in Nigeria; Maradi in Niger, Mubende in Uganda; Boer in South Africa; and Criollo in Latin America and the Caribbean.

Small Ruminant Production Systems

Small ruminant production systems throughout the developing countries are divided into three categories as follows:

- Extensive systems
- Systems using biomass from:
  - — the by-products of arable cropping
  - — roadside, communal and arable tethered or grazing systems
  - — cut-and-carry feeding
- Systems integrated with tree crops such as coconuts or oil palm.

These production systems are unlikely to change in the foreseeable future. New proposed systems and returns from them would have to be demonstrably superior and supported by massive capital inputs and other resources (Mahadevan and Devendra, 1986; Devendra, 1989). However, it is quite predictable that there will be increasing intensification and a shift within systems, especially from extensive to systems combining arable cropping, induced by population growth and the fact that population density and intensity of land use are positively correlated (Boserup, 1981). This situation is increasingly likely with decreasing availability of arable land which will occur in many parts of South East Asia.

An analysis of these systems led to the conclusion that the principal objective should be to maximise the use of the available feed resources, notably crop residues and low quality roughages, and also various leguminous forages as supplements to maximum advantage in appropriate feeding systems. This conclusion is consistent with the findings of the consultation to define the global agenda for livestock research (Gardiner and Devendra, 1995) that feed resources and nutrition are the most important constraints affecting animal production across regions (Asia, sub-Saharan Africa, west Asia and north Africa and Latin America and the Caribbean). This has been further confirmed by two recent detailed assessments of livestock research priorities in South East Asia (Devendra *et al.*, 1997) and South Asia (Devendra *et al.*, 1998).

The reduced availability of land, and more particularly, critical feed and water shortages in these harsh environments have resulted in both nomadic and transhumant production systems. The movement of people and especially small ruminant populations is a characteristic feature of the semi-arid tropical region (SAT). During the height of summer and very high temperatures (30-40°C), these result in 4-6 months of animal movement of between 10-15 km per day, motivated by the search for grazing as well as wage labour opportunities. In

the Indian sub-continent, it is estimated that between 30 and 40% of the total small ruminant population is on the move. These movements are spectacular, are a way of life, and involve whole households along well defined routes with men accompanying large flocks of between 1200 and 3000 animals. Kids are often placed in baskets carried by camels. With the onset of the rains, and increased feed availability, grazing becomes more localised. In the more cooler hilly areas, goat flocks are stall-fed in the valley during winter, and migrate for grazing to alpine pastures during spring and summer, only to return in late autumn.

These distinctive annual nomadic and transhumant migrations, especially in the semi-arid and arid areas, are associated with several crop-animal interactions and problems. They include inter alia use of common property grazing lands, forest margins and varying degrees of the spread of diseases and social problems, resource degradation, e.g., trees for fodder and fuel. Some of these issues have been individually investigated, but a more holistic assessment of the circumstances and opportunities for improvement of the major constraints, including policy matters, remain to be considered in the context of integrated natural resource management and use. Thus, for example, animal health services for the landless pastoralists, and interventions to improve the marketing of livestock and livestock products, as well as the development of cooperatives, have hardly been considered.

Two main types of migratory systems are involved: (i) nomadism and (ii) transhumance. Both these systems are practised by the shepherds and represent highly rational adaptations of human life to a severe and adverse environment. It is a natural response to traditional livelihood under extreme limitations in a stressful environment. In many parts of SAT, nomadism and transhumance involve a very high percentage of the population. Nomadism and transhumance, mainly in arid, semi-arid and steppe conditions, are characterised by extensive husbandry. It is appropriate to briefly describe these systems.

Nomadism

Nomadism involves the regular movement of whole families and tribes in search of grazing and water. Flocks may consist of goats or sheep only, or mixture of both species and camels. Management practices are the outcome of centuries of adaptation to peculiar and difficult physical environment; a limited number of crops can be grown, but goat and sheep rearing is a principal livelihood. Poor water supply determines the traditional systems of grazing areas with sparse vegetation of mainly weeds.

During the long dry season, the goats are grazed close to watering points and are watered either daily or every other day. The hamlets are separate and independent of the camel camps and each family has its own separate pen for the goats and the sheep. Lack of grazing rather than lack of water is the motivation for nomadism. Camels that browse in the plains during the dry season are shifted into the mountains with the onset of rains. Cattle are confined to the mountains during the dry season and moved to the plains to take advantage of better grazing with the first rains. The flock sizes of animals are generally large,

and very important in economic terms (Raut and Nadkarni, 1974).

In Rajasthan in India, for example, large flocks of between 2000 and 3000 sheep and goats are involved in the migration. These start in Durg in Madhya Pradesh and proceed to Jaipur in Rajasthan, involving long distances of over 1800 km, till July-August of the following year. Usually, only men are involved in the movement. The sheep are often shorn on the way and the wool is sold at about US$0.30 to $0.40 kg^{-1}. Often the animals are also used for increasing the fertility of land of farmers through the return of dung and urine at costs of US$1.60 to $2.00 per night or 60-80 kg of grain in return.

Nomadism and transhumance are intimately linked to the social life of the people. Nomadic management of small ruminants has three features.

- Herd diversification - different species with their different grazing habits (for example, browsing by goats), reduce the probability of total loss of all animals.
- Loaning animals and sharing herds - this enables sharing livestock with others in another area if there is a drought. Also, social contacts are strengthened.
- Movement of herds - this is an obvious strategy for survival and includes various types of migrations: seasonal, short-distance or long-distance migrations to overcome any disaster.

Transhumance

Transhumance or semi-nomadism is also basically a migratory system, but it differs from nomadism in that usually it also involves some shifting of arable cultivation in rainfed areas or even sedentary systems in villages, rural fringe areas or at oases during certain seasons of the year.

Several patterns of alternating sedentary crop cultivation with migration to grazing areas exist in different parts of the world, mainly in semi-arid areas or areas with extended dry periods:

- Alternation between winter quarters in the plains and summer mountain grazing areas; there may be an overlap between transhumants for summer grazing.
- Winter grazing in desert areas, summer grazing in oases and irrigated cropping areas.
- Grazing in plains and valleys which are left during the rainy season when they are flooded and cannot be used.

Usually, the grazing areas are public lands and not individual properties between tribes and families. There are traditional rights for grazing and use of watering points. However, because of increasing pressure on rangelands, from crop to forest areas, these rights are less and less observed and range management is deteriorating. The resulting damage is often attributed to goats. During the cropping season, the animals are often handled by children or left to fend for themselves, or entrusted to hired shepherds.

The poorer quality of land in the SAT is often referred to as marginal, wasteland, rangeland, threatened or fragile ecosystems. These include extensive lands in SAT that are generally used for crop cultivation, forestry or urbanization. The estimated land area under SAT is uncertain. Rangelands in Pakistan constitute about 60% of the

land area, equivalent to about 51 x 10^6 hectares (Noor Mohammad, 1989). A study commissioned by the Society for the Promotion of Wastelands Development in India found that about 129 x 10^6 ha of land was degraded, equivalent to 39% of the nation's land area. World Resources (1988-89) estimated that dry lands accounted for about 237 x 10^6 ha in Asia, of which there were 134 x 10^6 ha or 20% of the total land area in South West Asia.

Large concentrations of ruminants are found in these lands which require no commercial energy to produce meat, milk, wool, hides and other animal products. Several millions of poor people are found in these areas, a large proportion of whom are wholly dependent on animals. Much of the land of about 5 x 10^6 ha in Baluchistan in Pakistan, and about 49 x 10^6 ha of poor quality land in India, fall within the SAT.

In India, it has been estimated that 86% of the farmers own less than two hectares of land. Additionally, 70% of the people in SAT are rural-based. These people depend primarily on rainfed food production, the importance of which is reflected in 90% of the sorghum, millets, oilseeds and pulses being grown in SAT. Several cropping patterns have evolved in which cereal-legume combinations perform best. Generally speaking, poor price incentives, marketing infrastructure and processing technology limit competition of these crops with other grain. In turn, this has also influenced the extent of technology adoption by farmers.

Water is the most limiting factor for dryland crops. Water management is generally poor within SAT, and if this can be made accessible, it could significantly increase yields of sorghum and millets.

Many farms are becoming uneconomical in the SAT. Lack of assured markets, subsistence nature of farming, farmers' continued worries that investments and inputs are risky, are some of the reasons for this. Capital accumulation through the ownership of animals is a viable option in SAT, but the main limiting factor is the availability of adequate feeds which is determined by total rainfall. Measures to increase feed production can influence the carrying capacity of the available land.

Loss Minimizing Strategies

Poor farmers in SAT practice a variety of loss-minimizing strategies to sustain life in the difficult environment. These include the following:

- Diversification
  - — Agricultural practice, e.g., Crops
  - — Income sources
- Reallocate resources

  e.g., favorable conditions increase crop area
- Mixed cropping or crop mixtures
- Early season changes
- Adjustment in sowing, transplanting dates, seed rates and planting spaces
- Increased investment on animals, especially goats and sheep
  - — "Banks" on hooves
- Household survival mechanism
  - — Asset disposal, e.g., Animals
  - — Credit

Seasonal
Response to crisis

— Land mortgages

- Off-farm activities.

Increased investment on small ruminants is a natural response of poor farmers in harsh environments, as it is linked to reduced risk, increased security, survival and food security. However, there are negative consequences on the environment, notably in overgrazing and increased pressure on land use.

Gender Issues

Women are generally the most disadvantaged, and the most vulnerable of the victims of extreme poverty. For these reasons, women and children are closely associated with the ownership and management of small ruminants throughout the developing countries. In many situations, the management of small ruminants is more the purview of women than that of men. This is the case in the Altiplano region of Latin America, most sub-Saharan countries, the Indian sub-continent and South East Asia. During droughts and migrations, women take on the added responsibility of collecting supplementary fodder for the animals.

In Upper Volta, Mossi, Fulani and Rimalbe women own goats and consider them as investment. Mossi women in particular view them as an insurance against famine. In Mali, a survey of five villages among the Marka, Peuth Rimaibe and Cuerga ethnic groups showed that goats and sheep were mostly owned by women, either through inheritance, or through purchase with income from selling agricultural produce. Ownership represents prestige and security to the women in case of divorce or seasonal migration of the husbands, and allows them to meet family and social obligations such as in the purchase of clothes, care of sick children and ceremonial costs (Safilios-Rothschild, 1983).

In Indonesia, results of socio-economic surveys indicated that the women's share of involvement in rearing small ruminants increased with increasing number of animals reared. Additionally, literate women were more involved in the physical activities of management (herding, grass cutting, feeding, watering and health control) than in decision making (planning and marketing) probably because of their perception of the animal's needs. Illiterate women, by comparison, involved their husbands in all activities, as well as in the decision making process (Wahyuni *et al.*, 1985).

A contribution to stable households and distressed women is also significant. In Bangladesh, distribution of goats to such women provided more security. More importantly, monitoring of returns after two years, from 11 such women, each with an initial investment of a doe costing about US$11, provided additional income of between US$38.5-134.0 (Saadullah *et al.*, 1996). Experience with other NGO's also suggest that parallel to the redistribution of goats, the recovery of loan money from women was very much higher than from men, suggesting strong commitment, and a powerful development opportunity. It is not surprising therefore that in Bangladesh, credit for purchasing goats, specifically by women, is being increasingly encouraged.

The conclusions from the various studies as well as field observations, suggest that the distribution of goats resembles that of extending rural credit, except that with reference to women, the benefits are direct and perhaps more permanent. These include household nutrition and alleviation of hunger, improved livelihoods, utilisation of unpaid family labour more fully, more stable households, and increased self-reliance.

Land Use Systems

The task of producing more food will increase the pressure on how the land and natural resource base will be managed and used. As it is, serious environmental problems have already arisen. Rapid industrialisation and urbanisation have resulted in chronic air and water pollution. In the rural areas, rapidly increasing human populations have led to increased pressures on limited natural resources, and the need for increased fuelwood, with resultant deforestation and deterioration of soil quality. This has caused increased exploitation of the forest cover, often without regard to the need for replanting and maintenance of environmental integrity. This is especially evident in Nepal, India and Pakistan. In these situations, poverty alleviation and environmental protection are often in conflict, but need to be addressed simultaneously (Leonard, 1989).

FAO (1988) analysed the total area harvested between 1982 and 1984 and reported that for Asia, 60% was high potential land, 21.8% was problem land and 18.2% was low potential land; the latter falls in the SAT. The same study projects that for Asia excluding China, there will be a small increase in agricultural land, much of which is related to irrigated agricultural land and tropical forest areas. There will be increased pressure on land for industrial and recreational needs, as well as urbanization. It is also estimated that about 7.5×10^6 ha of arable land is lost globally annually through soil degradation and a further $1\text{-}5 \times 10^6$ ha as a result of waterlogging, salinization and alkalisation; many parts of Asia are also involved in this loss (FAO, 1991).

Increased food production in the future can be achieved in the following ways:

- increasing existing arable land to include crop-animal systems,
- intensifying the use of existing land, and
- expanding production to include unused land.

Of the three approaches, it is doubtful if further dramatic increases are going to be achieved with new germplasm and the use of costly external inputs, on existing land. Maximum production has already been reached and is levelling off. Intensifying the use of arable land area to include crop-animal systems can provide some increase in production through more efficient use of natural resources and by integration. In areas where such integrated effort has not been adequately practised such as in the countries of Indo-China (Vietnam, Laos, Cambodia and Myanmar), involving non-ruminants and also China, the system has considerable potential. Likewise, integrated small ruminant-tree crop systems in many parts of South East Asia has not been adequately explored, and has considerable potential to promote sustainable development and achieve economic impact (Devendra, 1993).

Table 4. Economic contribution of small ruminants to total farm income in Asia

S.No.	Animal product	Location	Result	Reference
1.	Goats and sheep	India	27.2-32.8%	Raut and Nadkarni (1974)
2.	Goats	India	Return per unit of rupee was higher[2]	Chauhan and Balishter (1983)
3.	Goats and sheep	Indonesia	7.1% -- lowland 25.9% -- rubber plantation 13.9% -- upland	Knipscheer *et al.* (1983)
4.	Goats Milk Manure	India	75.8% 19.7% of total income 4.5%	Kumar *et al.* (1986)
5.	Goats Milk Manure	India	13.4-30.0% 66.6-84.8% of total income 1.0-3.4%	Singh and Ram (1987)
6.	Goats and manure	Pakistan	46.9% of total costs	Amir (1988)
7.	Goats	China	50-55% of total income	Devendra (1992)
8.	Goats	Indonesia	16.7-20.3%[3]	Devendra (1992)
9.	Goats and milk	Vietnam	58%	Devendra (1992)
10.	Goats and sheep	India	Goats were more remunerative than sheep	Oberoi *et al.* (1992)
11.	Goats Milk Manure	India	30.1% 68.9% of total income 1.0%	Deoghare and Bhattacharyya (1993)
12.	Goats Milk Manure	India	43.1% 54.0% of total income 2.9%	Deoghare and Sood (1994)
13.	Goats Skin	Pakistan	net profit shown	Iqubal *et al.* (1994)
14.	Goats Milk Manure	India	30.7% 67.8% of total income 1.5%	Deoghare and Bhattacharyya (1994)

[1] As % of total cost of production in stationary and migratory herds.

[2] Compared to buffalo in studies on both marginal and landless farmers.

[3] Based on a farming systems study (1985-1991) in Batumarta, Indonesia, involving cash crops, rubber, cattle and also indigenous poultry.

Expanding production on unused land, especially in SAT, clearly represents an area that requires greater attention in the future. The problems are complex and more difficult, are not insurmountable, and now justify increased resource allocation, research and development efforts.

Economic Contribution

It is appropriate to assess the nature and extent of the economic contribution of small ruminants. Table 4 summarises the situation-specific case studies in a number of countries in Asia. The components of income generation are sale of animals

for meat and breeding, milk and manure in decreasing order of importance. The magnitude of these individual component contributions from Table 4 were: sale of animals 27.2-75.8%, milk 19.7-84.8%, and manure 1.0-4.5% of the total farm income.

Attention is also drawn to the other aspects of results in a number of studies cited, involving both rainfed lowland and upland areas in both semi-arid/arid and sub-humid/humid regions (Devendra, 1996):

- For migratory herds in semi-arid areas involving the poorest farmers and the landless (Raut and Nadkarni, 1974; Kumar *et al.*, 1986; Deoghare and Bhattacharyya, 1994), goats and sheep presently provide a most valuable source of income. In these studies, the sale of animals and milk provided between 27.2% and 84.8% of the total farm income.

- In these same situations, raising goats is often the principal source of income, and often the main means of survival, especially in harsh environments such as in Cholisthan in Pakistan and Rajasthan in India.

- In the humid countries in South-East Asia, goats and sheep also produce an important, but evidently low level of income (Devendra, 1992).

- A study in the lowland and upland areas in Indonesia (Knipscheer *et al.*, 1983) is interesting in that it suggests a higher contribution from the upland areas (39.8%) compared to the lowlands (17.1%) by small ruminants to total farm income. This observation is consistent with the data in Table 2 concerning the high concentration of small ruminants in upland areas.

In addition to these, there is also growing evidence that both species make a valuable contribution in the development of sustainable agriculture. This is reflected in for example, the development of several important production systems in various agro-ecological zones. These include the three strata forage system (grasses and ground legumes, shrub legumes, and fodder trees, respectively) which is a way of conserving the feed requirements of cattle and goats, in Indonesia; integration of goats and sheep with coconuts in the Philippines and oil palm in Malaysia; integrated rice-fish-duck-goat system in Vietnam, Thailand and Bangladesh; alley farming involving *Leucaena* or *Gliricidia* or *Flemingea* in the Philippines and Nigeria; and the integration of dairy cattle and goats with cropping in the Kandy forest garden system (coconuts, fruits, root crops and herbs in stratified layers) in Sri Lanka.

Post-Production Aspects

One aspect of the economic importance of small ruminants that is inadequately addressed in most countries concerns post-production. In animal production systems, it is especially important to link production with post-production systems in which there is organized collection, transportation and marketing to include products and by-products from them. These aspects are generally neglected throughout the developing countries resulting in:

- Reduced revenue to farmers. Observations in several countries in Asia suggest that farmers generally receive 55-60% of the total value of the animal, the

remaining 40-45% going to middlemen and/or butchers whose total effort in terms of production process time is about one to two days.

- Reduced revenue from the sale of animals as well as their products. These involve the meat, skins, by-products and derivation of value-added products from skins. Recent studies in India indicate that goats transported for more than 400 km for 15-38 hours showed weight losses of 9-10% which in quantitative terms is quite high. These data exclude losses also due to the effects on poorer quality products, by-products and also herd wastage (Naidu *et al.*, 1991).

- The animals slaughtered specifically for meat production are of doubtful quality. In several countries, animals from unknown background and production systems with no reference to consumer preferences are slaughtered at random. The majority of animals sold (70-80%) are 1-2 years old.

- Where the demand for both meats and consumption is widespread, and organised programs are not in place, there is serious erosion of the breeding population in which increasingly younger animals are slaughtered. The net effect is reduced output of goat meat. Surveys in two states in India indicated that 50%-73% of the goats slaughtered were below six months of age, and 26-50% were 6-12 months of age (Naidu *et al.*, 1991). The cument status and development of post-production systems was recently discussed in India (Naidu *et al.*, 1997).

The components in post-production systems that merit attention are:

- Collection - methods of collection including transportation are important since these affect slaughter weight;

- Handling - includes mode, duration and management during transportation;

- Marketing - distinct outlets, organisation and their capacity;

- Slaughter facilities - size, adequacy, hygiene, strategic location, and methods of salvage by-products;

- Consumer requirements - nature, extent and characteristics. These need to be addressed in relation to changing trends (preferences, incomes and purchasing power).

Opportunities for Research and Development

Rainfed lowlands and uplands

Agricultural development in the past has over-emphasised the use of the lowland irrigated areas with spectacular increase in cereal production. However, since arable land is scarce, attention now needs to shift to the underutilised rainfed, lowland and upland areas. The justification for this is linked to the magnitude and relative concentrations of small ruminants (goats and sheep) in these areas (Table 2). These sizeable populations depend exclusively on the available feed resources which result mainly from crop production. Variable feed production, as well as the seasonality of production and drought periods of variable lengths seriously hamper productivity. In many situations therefore, strategic supplementation to ensure optimum performance of animals is essential.

Since these rainfed lowlands and upland areas are fragile and also complex, research and development efforts will be more difficult in these harsh environments but holistic, multi-disciplinary efforts are more than likely to provide major benefits, increased productivity and impact. A farming systems approach is necessary to understand the components and complex interactions in the systems to improve and intensify the production systems. Existing systems need to be thoroughly characterised, constraints and research opportunities identified to address production and post-production constrains.

A concerted interdisciplinary research programme is necessary that addresses the following:

- Detailed socio-economic assessment of the nature of the production systems and the relationship between poor people, resource use and the environment.
- Assessment of the relationships between pastoralism, agropastoralism, transhumance, flock dynamics and the environment, and their interactions.
- Identification of the major constrains affecting production.
- Quantification of nutrient supply (through manure and urine), improvement to soil fertility, and effects on crop production.
- Effect of improvement and interventions, e.g., feeds from multipurpose trees on the production systems, including social-economic and environmental assessment on the systems.
- Improvements in post-production processes.

Use of available breeds

Given the considerable genetic diversity in Asia, increased efficiency in the use of the available breeds is essential. In particular, much greater use can be made within species of several "improver breeds" in a manner that is consistent with clear production objectives, better understanding of indigenous knowledge and traditional systems of management, and improved use of the available production resources. In general, breed improvement programmes have not made wider use of indigenous breeds and failed to focus on their selection and increase per animal performance. It is equally important to ensure conservation of the more important germplasm.

Nutritional strategies

Feeding and nutrition represent the principal constraints to production, and strategic intervention is a most important means of increasing the productivity of goats. The situation has recently been reviewed in depth (Leng and Devendra, 1995) and involves the following approaches:

- intensifying the use of crop residues which include:
  - — improvement of potential digestibility;
  - — strategies to enhance rumen function;
  - — manipulating net rumen microbial growth;
  - — provision of by-pass nutrients;
  - — demonstration of profitable responses;
  - — ensure post-production facilities for efficient marketing.

- enhancement of the utilisation and digestibility of straws through alkali treatment; and
- strategic supplementation.

Utilisation of research results and on-farm interventions

The use of research results and improved technologies are responsive and important approaches to overcoming existing constraints. Given the diversity of many important small ruminant breeds, the focus should be on addressing non-genetic factors such as improved nutrition, which is especially critical and the major constraint throughout Asia (Devendra *et al.*,1997; Devendra *et al.*,1998). The approach should be aimed at providing a balanced feed supply, balanced energy/protein ratios, and correcting any critical nutrient deficiencies with low-cost supplements. Increased use of leguminous forages as several studies have already shown, can make a significant contribution to the nutrition of small ruminants.

On-farm interventions are especially important and merit very high priority. An essential pre-requisite for this is detailed diagnosis of the dynamics of small farm systems that are sensitive to socio-economic issues and changes. The components of this approach are:

- understanding of traditional systems;
- problem definition;
- formulation of appropriate interventions based on real rather that perceived needs;
- integration of interventions into effective development policy; and
- demonstrable impact at the farm level.

Community-based participation

Greater community-based and also private sector participation is especially valuable in alleviating constraints to small ruminant production. It includes creating greater access to agricultural services, inputs, credit and also more active decision-making and management of small holding farmers' own affairs, including common property issues. An additional dimension associated with community-based participatory processes is the involvement of women. Considerable evidence and information clearly point to the fact that women are closely associated with the management of goat and sheep production. Gender issues thus merit special attention in program formulation and implementation.

Conclusions

Small ruminants are essential components of the natural resources in Asia. The population sizes, increasing numbers, distribution across various agro-ecological zones reflect an important economic and ecological niche in mixed farming systems. Despite this importance however, resource allocation by national programme and donor agencies is generally weak, for research and development projects commensurate with the importance of both species. The strategy for increasing their contribution is directly linked to major challenges and opportunities for research and development that are consistent with more efficient use of the available breeds, targetting the poor, and wider use of improved technologies that can ensure environmentally sustainable agriculture in Asia.

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