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- Invited Review – Investments on Pro-poor Development Projects on Goats: Ensuring Success for Improved Livelihoods*

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ABSTRACT: The elements that determine the success of development projects on goats and the prerequisites for ensuring this are discussed in the context of the bewildering diversity of goat genetic resources, production systems, multifunctionality, and opportunities for responding to constraints for productivity enhancement. Key determinants for the success of pro-poor projects are the imperatives of realistic project design, resolution of priorities and positive impacts to increase investments and spur agricultural growth, and appropriate policy. Throughout the developing world, there exist 97% of the total world population of 921 million goats across all agro-ecological zones (AEZs), including 570 breeds and 64% share of the breeds. They occupy a very important biological and socio-economic niche in farming systems making significant multifunctional contributions especially to food, nutrition and financial security, stability of farm households, and survival of the poor in the rural areas. Definitions are given of successful and failed projects. The analyses highlighted in successful projects the value of strong participatory efforts with farmers and climate change. Climate change effects on goats are inevitable and are mediated through heat stress, type of AEZ, water availability, quantity and quality of the available feed resources and type of production system. Within the prevailing production systems, improved integrated tree crops - ruminant systems are underestimated and are an important pathway to enhance C sequestration. Key development strategies and opportunities for research and development (R and D) are enormous, and include *inter alia* defining a policy framework, resolution of priority constraints using systems perspectives and community-based participatory activities, application of yield-enhancing technologies, intensification, scaling up, and impacts. The priority for development concerns the rainfed areas with large concentrations of ruminants in which goats, with a capacity to cope with heat tolerance, can be the entry point for development. Networks and networking are very important for the diffusion of information and can add value to R and D. Well formulated projects with clear priority setting and participatory R and D ensure success and the realisation of food security, improved livelihoods and self-reliance in the future. (**Key Words:** Pro-poor, Poverty, Goats, Improver Breeds, Development Projects, Climate Change, Food Security, Rainfed, Genetic Diversity, Conservation, Strategies, Policy, Agricultural R and D)

INTRODUCTION

The search for efficiency in the use of available production resources represents a major objective in agriculture throughout the developing world. This objective is consistent with approaches to reduce and alleviate poverty, low agricultural productivity, natural resource degradation and protection of the environment. The fact remains that these issues remain to be resolved to the extent possible for a variety of reasons. The key factors associated with the latter include *inter alia* waning agriculture. Inadequate investment in the agricultural sector, poor yield-enhancing technology application, and weak community-based linkages with research that are also identified with poor delivery systems in priority AEZs. The latter areas include the semi-arid and arid tropics of Sub-Saharan Africa; South Asia; highlands of East and Central America; Central, Central Africa and Central America; and the Caribbean and South East Asia.

Associated with the decline in agricultural productivity is the dichotomy and disparity between high potential favored areas and low potential less-favored areas. The former relates to high agricultural potential, good soils with high fertility, good rainfall, minimum biophysical

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constraints, have good access to infrastructure, technology, credit and markets. Not surprisingly, large investments have tended to go towards these areas, urbanisation has increased together with increased population growth. A significant point is that there is increasing evidence of yield stagnation and diminishing returns from these areas.

Conversely, the less-favored areas are have numerous biophysical constraints e.g rainfall. These are the areas that have been by-passed by investments, land degradation is severe, with resulting increased population are poor people with severe poverty which currently are estimated to be in excess of 1.8 billion people. The conclusion from a consideration of these interrelated facts, is the widespread view that the less-favored areas with some pockets of good potential lands not already adopted. Merit more investments and development attention in the future, particularly in the context of poverty alleviation, food security and environmental integrity.

In these areas as with others, increasing agricultural productivity is essential for stimulating economic development and reducing poverty. In general, rainfed agriculture in many of these regions if not all is stagnant, with increasing degradation of the environment, and continuing poverty. The situation is exacerbated by the loomig threats and effects of climate change. Raising agricultural productivity is therefore essential, as the pathway complements natural resource conservation, and requires improved, management of soils, water and nutrients. These developments will also need to be supported by increased infrastructure, access to technology, markets and institutional credit. Infrastructure investments have generated marketing avenues for crops and animal products like milk, whose production has also led to the formation of strong village-based cooperatives.

Throughout the developing countries, goats are seen as important multifunctional animals, in socio-economic and ecological terms. This is reflected in their wide distribution and ownership by resource-poor small farmers, and also the landless. The diversity of goats is integrated into farming systems in all the ecosystems, without exception-in which they serve a variety of key functions. The main one is the contribution to nutrition and food security, and in the harsher environments, sheer survival of the poor communities. In the latter environments, their value and importance increases with decreasing availability and quality of the production resources.

They play a very useful role and also make a very valuable multifunctional contribution especially to the poor in the rural areas. Of particular importance are their contributions to food and financial security, stability of farm households and survival. These key issues are often overlooked, and taken for granted with the perception of general unimportance, and the ability of the species that it can survive without much intervention. It is also relevant to observe that despite the size of about 97% of the total world goat population being found in the developing countries, investments on research and development (R and D) have been generally small relative to the funds involved with other species such as cattle and sheep in developed countries.

NATURAL RESOURCES

Asian agriculture is based mainly on integrated management of natural resources, is an important determinant of economic growth and technologically driven transformation. The impacts of successful economic development through the "Green Revolution" of the 1960s and beyond are testimony of this fact. The sector is central to the efficient use of the natural resources, and the emerging challenges, and is directly concerned with the following key issues:-

• Availability, management and use of the natural resources (land, crops, animals and water) that is consistent with maximising agricultural growth and productivity to the extent possible.

• Enhancing food security

• Reducing hunger, poverty and the vulnerability complex

• Many of the technologies developed for agriculture to enhance productivity do have beneficial impacts on human health and well-being e.g. food-feed systems

• Stability of human livelihoods and households

• Development of adaptation and mitigation options to cope the climate change; and

• Application of integrated systems perspectives to cope with climate change.

Associated with integrated natural resource management (NRM) is the interdependence of agriculture and the poverty complex, involving several millions of poor people. The majority of these rural poor rely and indeed survive because of the reliance on agriculture. An estimated 60% of the working population and generating 25% of the region's GDP are involved with agriculture. ESCAP (2008) has estimated that agriculture alone can lift the estimated 641 million people out of poverty, and that a 1% increase in agricultural productivity would lead to a 0.37% drop in poverty in the Asia-Pacific region It was clear that further progress was limited without necessary intervention and the infusions of new technologies.

While agricultural production, consumption and trade are pivotal, the fact remains that food insecurity, poor access to food, poverty and hunger are widespread and widening in the Asian region. It is pertinent in this context to note that an estimated two thirds of the world's poor or 641 million are found in Asia and the Pacific, of which

some 70% of the poor are associated with agriculture. The effects of globalisation and other externalities have the poor people very vulnerable.

The agriculture sector also produces non-food products like biofuels and rubber which are of much economic importance and a variety of important services:

• Links system components (land, crops, animals and water), small farmers and the landless
• Agricultural growth provides for pro-poor initiatives and environmental sustainability
• Enables links to several component industries like food processing and feed milling
• Promotion of nutritional and food security
• Foreign exchange savings from exports e.g. of staples and imports; and
• R and D and innovation link agricultural science and society, resolution of problems of farmers, and scale-neutral technology application and adoption.

The traditional role of agriculture is its direct contribution to the GDP, foreign exchange earnings, export growth and trade (Johnston and Mellor, 1961). It plays a significant role in Asia: value addition in 2005 of 10% and 17% for East Asia and the Pacific and South Asia, respectively (World Bank, 2007). However, agriculture appears neglected, and the share of agriculture in GDP has declined significantly, due to low productivity resulting in slow growth (ESCAP, 2008). In East Asia and the Pacific for example, this has dropped from 3.0% in the 1980s to a mere 0.1% in 2000 to 2003.

In the rural areas, there is an extremely high correlation between the ownership of goats and poverty (Devendra, 1992). The implication is that where goats are found in the drier ,fragile and less-favoured environments, the probability is very high that there is a high incidence (<1$ US per day) of poverty. It is a most important attribute of the species that it can support financial and food security, livelihoods and survival in these harsh environments.

The development of goats is hampered by low productivity, resulting in their multifunctional production potential being seldom secured, in terms of precious animal proteins (meat and milk), fiber, skins, draught power in the highlands, food security, stable households and survival. The importance and extent of the contributions are inadequately understood, as a consequence of which potentially valuable goat genetic resources continue to be generally neglected. This in turn contributes to low R and D investments to improve the relatively low level of contribution which underestimates their potential importance to enhance productivity.

The purpose of this presentation is to provide a comprehensive discussion on perspectives on goats and production systems with reference to the improved use of genetic resources. There is a real need to increase the contribution from goats to food production in the face of several demand-led factors which *inter* alia include population growth, urbanisation, income growth, inability of current supplies to match requirements, and changing consumer preferences. This situation is further exacerbated by inefficiencies in animal production systems and natural resource management that are unable to respond to the need for increased supplies of foods of animal origin, promotion of improved livelihoods and rural growth.

PREREQUISITES FOR AGRICULTURAL GROWTH

Increased agricultural and economic growths have in the past had major impacts on alleviating poverty in Asia. This has been achieved in agriculture through environmental considerations, efficient natural resource management (NRM), increased productivity such as been seen in the 'Green Revolution', and good returns to farm labour. For agricultural growth to be pro-poor, it has been suggested that the following attributes are important (Rosegrant and Hazell, 2000):

• A technology package that can be profitably adopted on farms of all sizes
• A relatively equitable distribution of land with secure ownership or tenancy rights
• Efficient input, credit, and product markets so that farms of all sizes have access to needed modern farm inputs and receive similar prices for their products
• A labour force that can migrate or diversify into the rural non-farm economy, and
• Policies that do not discriminate against agriculture in general and small farms in particular (for example, no subsidies for mechanisation).

Poor people are disadvantaged in a multitude of ways, the elements of which are various interrelated issues *inter*

Plate 1. Small animals play a most important role in providing precious animal proteins to the poor to offset malnutrition and poverty. Photo shows a woman and her children feeding native chicken in Binh Phouc province in Vietnam (C. Devendra).

alia: chronic hunger, malnutrition and ill health, inadequate or no access to most amenities, deprivation and despair. These together have resulted in a continuing syndrome of a *poverty - adaptation - fragile lives - little hope - low life expectancy complex* (Devendra and Chantalakhana, 2002) (Plate 1).

Most countries in Asia including Malaysia started as agrarian economies with emphasis on rural development in which the thrust in agriculture was on crop cultivation and especially crops with export potential (e.g. cassava, cocoa, oil palm and rubber). Historically, agriculture invariably contributed to the largest share of the gross domestic product (GDP). Agricultural growth was led by the technology and supply driven "Green Revolution" which brought with it much affluence for farmers and significant increased productivity. The pace of agriculture-induced economic development was then followed by the growth of the non-agricultural sector, especially the manufacturing and service sectors. The resulting effect was a secondary role for agriculture that was associated with variable outputs, declining agriculture and decreased share in the GDP, increased labour productivity, and spectacular economic growth.

Figure 1 illustrates the development pathways in the process of economic transformation. In Malaysia, support for the development of agriculture has been minimal, but the sector has continued to make significant contributions in many ways. A combination of diversification of agriculture, and the finding that tree crops, notably oil palm, rubber and cocoa were well suited to the Malaysian environment led to a rapid shift and expansion to tree crop-based agriculture. The strategy emphasised the following:

• Pursue the comparative advantage of diversification of natural resource-based commodity exports in which oil palm, rubber and cocoa were prominent

• Intensively invest substantially in R and D on commodities to remain competitive in tandem with the private sector

• Influence of government and markets on resource allocation and the dynamics of growth, and

• The emerging sequential phases were: commodity exports, import substitution, and export manufacturing.

This development had three important effects. Firstly, natural resource-based commodity exports enabled the generation of significant foreign exchange earnings and helped the country to leap frog from an agriculture base to a strong industrialised non-agriculture setting. Secondly, less emphasis and development attention was given for promoting higher value foods like fruits, meat and milk. Lastly, increased affluence and per capita incomes began to fuel diet diversification and increasing imports of higher value.

The leap frog from the agriculture base to resource-

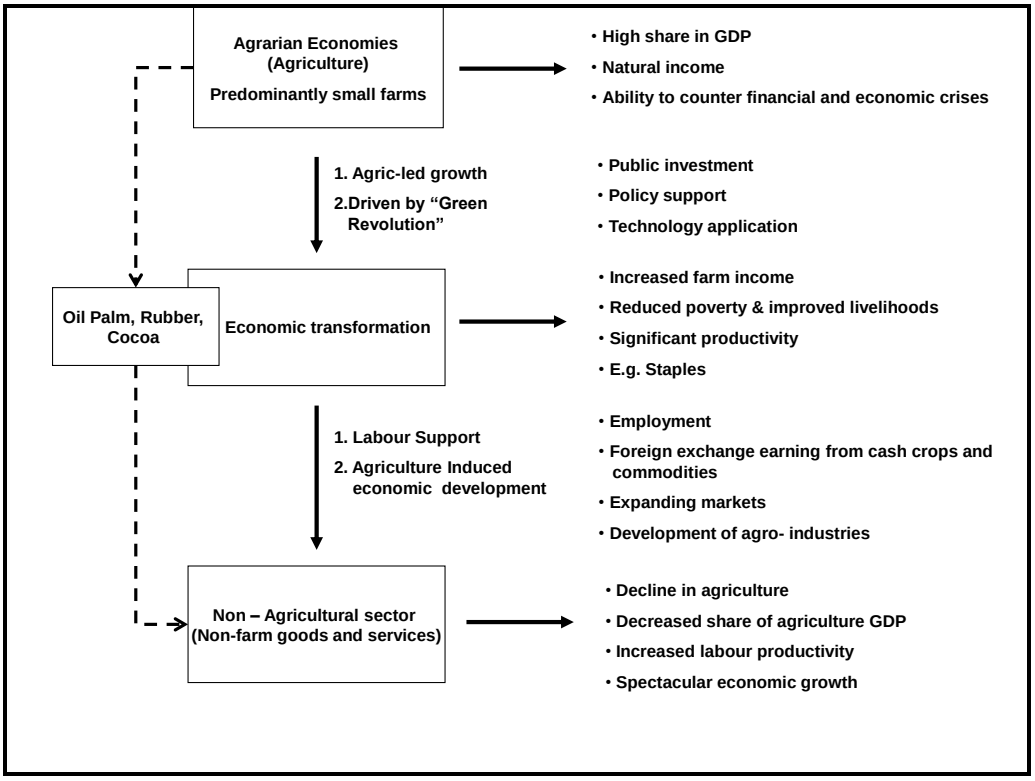

Figure 1. Development pathways and economic transformation in agrarian economies in general and Malaysia in particular (Devendra, 2011).

based industrialisation, while greatly beneficial to Malaysia, did little to balance with the development of agriculture. Rice fields gave way to export processing zones and electronic factories, together with rice production having no competitive margin over Thailand, which successfully exports rice. The result was a concurrent trend for import substitution. This is unlike the situation with Indonesia, which in addition to the export crops also invested heavily on food crops to increase their productivity at lower costs, as also on non-food products like wood for home consumption.

The relationship between the growth in the agriculture sector and the combined manufacturing and services sector indicate that countries with higher agricultural growth also recorded higher growth in non-agricultural activities. During 1975 to 1995 Indonesia and Malaysia for example fall almost directly on the fitted line to reflect this relationship, with the annual *per capita* average growth in agriculture of 1.70% and 1.26% respectively, pushing growth in the manufacturing and service sectors of 6.23/yr and 5.34/yr.

INCREASING GROWTH TO ENHANCE WANING AGRICULTURE

Throughout most of Asia, investments and the development of agriculture are both on the decline, and the reasons for these are of concern. It has recently been reported (ESCAP, 2008) that the sector involves a large proportion of the region's surface, provides jobs for 60% of the working population in the Asia-Pacific region, and generates a quarter of the regions' total GDP. Associated with these, the reliance on agriculture is especially significant as it provides a number of services to mankind. Low product prices, high input prices and higher value addition in industry and services have also made agriculture less attractive. Low productivity and resulting slow growth are apparent. Between the 1980s and 2000 to 2003, growth in agricultural output in South Asia dropped from 3.6% in the 1980s to 3.0%, and in East Asia and the Pacific from 3.0% in the 1980s to a mere 0.1%. It was clear that further progress was limited without necessary intervention and infusions of new technologies.

Waning agriculture and its neglect is evident, in which the share of agriculture in GDP has declined significantly. The fall in agriculture's share in GDP between 1965 and 2004 is reflected in the following data (ESCAP, 2008): East and North East Asia: from 53 to 9%; South and South West Asia: from 35 to 17%; and South East Asia: from 30 to 11%.

Associated with waning agriculture and decreasing productivity is the impact on poverty. It has also been reported (ESCAP, 2008) that while poverty is declining, this has slowed since the 1980s. In recent years there has been increasing evidence to underline the important relationship between agricultural growth and poverty. For the region as a whole, and using Thailand as the benchmark for productivity gains, it has been further calculated that about 218 million people can be free of poverty.

PRESSURE ON AGRICULTURAL PRODUCTIVITY GROWTH

The pressure on agricultural productivity growth is influenced by the many drivers of agricultural growth. These drivers of the current trends *inter alia* are as follows:

- Declining agricultural growth
- Continuing poverty and vulnerability
- Rapid population growth, food deficits and crises, consumer preferences
- Diet trends and changing food chains
- Vulnerability and survival of small farm systems
- Inadequate technology application, intensification of production systems and resources in holistic systems
- Reduced availability of arable land
- Globalisation and trade liberalisation
- Poor market access and opportunities for producers and products
- Increased environmental concerns and threats of trans boundary zoonoses, and
- Need for affirmative and collective action to address the emerging problems

THE SMALL FARM SCENARIO

Small farms, resource-poor farmers and the landless have the following characteristics:

Definition of small farms

Devendra (1993) defined small farms as complex interrelationships between animals, crops and farming families, involving small land holdings and minimum resources of labour and capital, from which small farmers may or may not be able to derive a regular and adequate supply of food or an acceptable income and standard of living.

Definition of small farmers

There are more definitions of small farmers, synonymous with the term smallholders, than small farms. It is important to stress that the rural poor are predominantly small farmers and landless agricultural labourers. The World Bank's Rural Strategy (World Bank, 2003) defines smallholders as those with a low asset base, operating less than two hectares of cropland.

Devendra (1983; 1993) has listed a number of features that characterise small farmers and the landless that are

unique to these individuals. These include *inter alia*:-

• They are essentially resource-poor people who face geographic isolation

• More numbers are usually found in harsh and less-favorable rainfed environments

• They continuously experience hunger and rural poverty

• They have the capacity to adapt and survive hardship

• They resist changes to avoid risks and capital investments

• They have little or no access to decision making processes and the use of new technology

• Being illiterate, they are not interested in extension materials

• Women tend to work more hours per day than men, and together with children are often involved in household chores and in the management of small animals

• They are not commercial producers of specialised livestock products and usually own 1 to 2 large ruminants, 4 to 6 small ruminants and/or a few indigenous pigs, poultry and ducks

• Large ruminants are owned primarily for draught power and secondarily for meat. Animals are reared for multi-purpose use, including the supply of dung and urine and transportation.

• They manage their animals as well as feed them from common property resources. Farm labour, including women and children, is often used for managing the animals

• They use meager farm resources rationally and strive to achieve complementary relationships between the animal and crop components in mixed farm enterprises

• Livelihood diversification is common to seek non-farm income to support the family and the farm. In these circumstances, women tend to take over many of the decision making and management of the farm, and,

• Small farmers except the landless have secured tenure and can pass on their land and assets to their families and children.

The overriding key descriptive words concerned with the livelihoods of small farmers are deprivation, subsistence, illiteracy, survival, and due to globalisation an additional key word is vulnerability (Plates 2 and 3).

PRIORITY DEVELOPMENT OF SMALL FARMS

The general neglect of small systems, and their by-pass for development by most national programmes and donor agencies, is a sad reflection of our times. The estimated total number of small farms is 470 million (below two hectares of land), of which 87% or 348 million farms and about two million resource-poor are found in Asia. Many of these farms are models of efficiency in natural resource management and low resource input systems, producing food for subsistence and occasionally for income. No hard data exists on the volume and extent of food produced on these small farms, but it is widely believed that this is of the order of 50%. To suggest therefore that small farms are not competitive, are inefficient and will disappear in time, is unacceptable and irrational. Development must therefore hasten to give very high priority to their development to increase agricultural productivity, food security and overcome poverty. Massive investments and appropriate ,policy is required for community-based programmes to address and enhance the plight of small farms, small farmers and the landless from the throes of the key descriptors of *deprivation, subsistence, illiteracy, survival* and *vulnerability*, whose lives are a non-ending syndrome of a *poverty - adaptation - fragile lives - little hope - low life expectancy complex* (Devendrá, 2011).

Plate 2. The photo shows a rice growing scene, typical of a high potential area in Andhra Pradesh, India. Such high potential areas are characterised by soils of high fertility, adequate rainfall, and good yields (C. Devendra).

Plate 3. A typical example of low potential rainfed area in Lesotho. These less-favored areas are characterised by poor soils and low fertility, erratic rainfall and high temperatures (C. Devendra).

SUCCESSFUL AND FAILED PROJECTS

In the formulation of project proposals that are realistic of needs and have the potential to promote efficient use of the production resources, the success or failure of individual projects, their analyses, discussions and lessons learnt form an important measure of the use of the investments. it is necessary to define these elements to keep the issues in perspective. The following definitions have recently been proposed (Devendra and Leng, 2011).

Successful projects

These are projects that are able to meet the objectives, contribute especially to food security and increased income, and show evidence of acceptance, adoption and replication by farmers. Additionally, the projects also demonstrate potential to contribute to self-reliance, stable farm households, and sustainable development. Successful projects also recognise systems perspectives, and are usually associated with effective participatory research-extension-farmer linkages, and are often associated with significant contributions by women to animal production. These issues also have to be sustainable or able to be modified as resource availability and costs escalate in the future. Close monitoring of the project till completion is essential till it is satisfactorily completed.

Failed projects

Failed projects that are associated with poor understanding and unsuccessful realisation of the objectives, inadequate technical know-how, are weak, do not have participatory application, have increased costs, do not fit into a time frame, and do not mesh with the farm calendar. There is also poor understanding of the value of systems perspectives and their application to complex crop-animal systems. The beneficial aspects in socio-economic terms are unrealised and not appreciated.

Consequently, the projects do not produce tangible impacts, are seldom considered for wider scaling up, testing and adoption on-farm. The poor results impede the incorporation of the technology to enhance scaling up and wider development of sustainable production systems. Failed projects are an unfortunate waste of funds, resources and reflective of poor project formulations.

DIVERSITY AND DISTRIBUTION OF GOAT GENETIC RESOURCES

The diversity and total population of goats concerning their global distribution of goats is reflected in the following:-

• The world population of goats in 2010 was about 921 millions, and includes a total of 570 breeds

• The developing countries owned about 97% of the goat population and 64% share of the breeds

• There also exist over 30 potentially important indigenous " improver breeds"

• The largest population was found in Asia (556 millions) followed by Africa (149 millions).These two continents together accounted for about 79% of the total world population and 42% of the breed share.

• Over the period 1986 to 2010, the average annual goat population growth and goat meat production were 2.3% and 6.5% per year respectively (FAO, 2010).

• Europe accounted for only 2% of the world goat population, but had a sizeable number of 187 breeds and 33% breed share, many of whom have been introduced for use in other countries.

Within Asia, the largest populations are found in India (35.2%), China (29.3%) and Pakistan (12.0%). These countries together accounted for about 84% of the population of goats and also the proportion of breeds. Corresponding to the relative populations 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 94.6% and 57.9% of the total world output respectively. These data reflects the relative importance of the species, but is also associated with species differences in fertility, income elasticity of demand for goat meat, and value to poor people throughout the developing countries.

Important breeds

The diversity of goats includes the presence in many developing countries of many "improver breeds" that is, those breeds that have such important traits as meat, milk, fibre or skins producing capacity, and are therefore potentially important for enhancing goat production (Devendra and Burns, 1983). "Improver breeds" are defined as potentially important and have the capacity to make a special genetic contribution e.g. growth rate, have above average performance, can enhance productivity, and are specially adapted to a difficult environment e.g. semi-arid /arid AEZ.

Among the 30 such breeds throughout the developing countries include such breeds as the Black Bedouin in Israel and Egypt and Ma'tou for meat from China; Katjang (meat) from Indonesia; Jamnapari, Barbari, Beetal and Malabar from India, Bac Thao (milk) from Vietnam and Sudanese Nubian from Egypt for milk; Black Bengal from India, Damascus from Syria and Lebanon, West African Dwarf goat from Nigeria for prolificacy; Kashmri for fibre from India; and Black Bengal from India, Maradi from Niger and Mubende from Uganda for skins (Plates 4 and 5).

Plate 4. On account of the poor fertility of the soil and high cost of fertiser animal manure becomes important for sustaining soil fertility. The photograph shows spreading of cow and goat dung to rainfed crop land in Nepal (C. Devendra).

Plate 5. South China black goats in extensive grazing systems in typical rainfed environments in Nanjian province, western China which is poorly developed, has poor natural resources and social infrastructure. Goats play a vital multifunctional role in poverty alleviation, survival and the entry point for the development of rainfed areas. However, control is essential to avoid environmental damage (C. Devendra).

Despite the apparent production attributes inherent in these breeds there is inadequate use of their potential within- country and the immediate region with comparable climates. The problem is exacerbated by failure to identify the attributes with clear production objectives and resource use to maximise production, as well as promote improvement programmes that can further increase the level of production. In these circumstances, there is an increasing tendency to resort to imports of one or more exotic breeds at very cost, the objectives of which are not very clear, and have the distinct possibility of creating genetic chaos in recipient countries. Considerable possibilities exist therefore to promote wider use both within as well as in other countries with similar climates, recognizing that there are disease issues that must be settled, together with the controlled use of chosen introduced breeds when their use is justified for specific reasons.

MULTIFUNCTIONALITY: PRODUCTS AND SERVICES

Goats contribute significant and extensive multipurpose functions of socio-economic and nutritional relevance. The products and services are especially important for socio-economic benefits, the stability and prosperity of poor farm households in Asia as is reflected in Table 1.

Products

The products from goats are meat (raw, cooked, blood, soup, goat meat extract - "Zeungtang" in Korea), milk (fresh, sour, yoghurt, butter, cheeses), skins (clothes, shoes, water/grain containers, tents, handicraft, shadow play in Indonesia, thongs etc.), hair (cashmere, mohair, garments, coarse hair rugs, tents, ropes, wigs, fish lures), horns and bones (handicraft) and manure and urine (crops, fish).

Services

Among the services that could be acquired from dairy

Table 1. Goat products and services in Asia (Devendra, 2007)

Products	Services
Meat (raw, cooked, blood, soup, goat meat extract -" Zeungtang" in Korea)	Cash income and investment
Milk (fresh, sour, yoghurt, butter, cheeses)	Security and insurance
Skins (clothes, shoes, water/grain containers, tents, handicraft, shadow play in thongs etc. in Indonesia)	Prestige in ownership
Hair (cashmere, mohair, garments, coarse hair rugs, tents, ropes, wigs, fish lures)	Gifts and loans
Horns	Religious rituals e.g. Sacrificial slaughter
Bones	Human nutrition - characteristics of meat and milk
Manure and urine (crops, fish)	Pack transport and draught power
	Draught power
	Medicine
	Control of bush encroachment
	Guiding sheep

With goats: Total edible proportion: 61%. Total saleable proportion: 82%.

goat production are cash income and investment, security and insurance, prestige in ownership, gifts and loans, religious rituals e.g. sacrificial slaughter, human nutrition, pack transport and draught power, medicine and control of bush encroachment.

PROBLEMS OF SMALL FARMS, SMALL FARMERS AND THE LANDLESS

Small farmers and the landless face numerous problems and constraints in the quest to be successful and productive. In this context they face numerous problems which inter alia are as follows:

• Management and coping with the diversity of activities: crops, animals, land, households, off-farm work
• Interactions
• Risk aversion
• Resource allocation
• Access to capital and inputs
• Access to markets and services, knowledge and technological interventions
• Cultural preferences and practices

LISTENING TO FARMERS

Farmers must be included in the core team all the way from programme definition, formulation, implementation to the realisation of impacts. Such an involvement is the essence of participatory effort in which farmers will be the ultimate beneficiaries of the totality of R and D efforts. The formulation of development programmes is futile if the intent and direction of these does not involve farmers as partners and the very reason to seek potential improvements to their livelihoods. There are many advantages of listening to farmers and their participation in the R and D. The major advantages of these are as follows (Devendra, 2006):

It is therefore important to invest time and resources to address this issue. In as much as research is meaningless if it is does not drive development, the formulation of development programmes is futile if the objectives being pursued are being implemented without specific intent and direction , and does not involve farmers as partners as a starting first.

• They know the bio-physical environment in detail
• They have full understanding of the major constraints and problems
• Research and development issues are identified
•They are the target beneficiaries of improved technologies
• They are also the targets for empowerment
•They have deep knowledge of local customs, and importance of indigenous and traditional systems
• Farmers are the agents of change and promotion of wide adoption
• They have all the local contacts
• Know current patterns of marketing and constraints
• Farmer are the target beneficiaries of sustainable livelihoods and sustainable development, and
• They enable understanding of the perceptions, preferences and aspirations, household stability, improved livelihoods and a better tomorrow of farming communities.

UNDERSTANDING KEY ISSUES

Associated with the need for identifying problems of farmers, is the need for better understanding of interrelated key issues. These include *inter alia:*-

• The genetic base: breeds, origin, their value and potential capacity
• The biophysical environment: notably rainfall, temperature, altitude and wind
• Available production resources- land, crops, water and feed resources
• Some knowledge of the prevailing farming systems in the bench mark sites (BMS),
• Assess marketing opportunities for increased agricultural productivity and the development of village-based development of cooperatives
• Assess potential opportunities for increasing productivity and poverty alleviation.

IMPERATIVES IN PROJECT DESIGN

There are a number of key considerations that merit detailed considerations that are directly linked to project design. These are as follows *inter alia*:-

• Human-induced climate change will push for extreme poverty and survival
• Search for efficiency in the use of available natural resources
• Defining the project objectives clearly in terms of production and profitability
• Understanding the significance and implications of soil-crop-animal interactions
• Ensuring that the resulting benefits and impacts are consistent with environmental integrity and sustainable development.

MANAGEMENT PREREQUISITES

From a management perspective, the following are important determinants that can significantly provide for ensuring successful projects. These include-

i) Strong and committed coordinator

ii) Very good links between researchers, farmers extension staff, and the local municipality

iii) Willingness to travel, meet, listen and work long hours with farmers

iv) Initiate early response to feedback and to problems

v) Receptive to cope with emerging problems, and

vi) Close monitoring.

RESEARCH THRUSTS ON GOATS A IN ASIA

An analysis and assessment of country research thrusts led to the following conclusions and following observations (Devendra and Liang, 2012):

• Breeding programmes are mostly haphazard, do not have clear objectives, suffer from the use of uncontrolled and different imported goat breeds without giving priority to producing large numbers.

• The situation further confirms the importance of fully using the available "improver breeds" to the extent possible, beyond which the imports of exotic goats is considered necessary.

• Country research thrusts continue to emphasise disciplinary lines.

• Both fundamental and applied efforts are apparent.

• Extent of needs-based farm-oriented research and development is unclear.

• More adaptive, interdisciplinary on-farm research R and development results are scarce.

• Issues on sustainability and development that have not been addressed.

Feeding and nutrition was considered to be the main constraint to production and most widely researched, with many attendant publications. However, the overwhelming majority of research projects are component technology type, often unjustified and not based on priorities. The tendency in much of the papers presented to continue along disciplinary lines was unfortunate and needs to be corrected. Much of the work as reflected below is component without any application and scaling up. For example use of *Indigofera zollingerian* as a forage protein source (Abdullah et al., 2012); use of rain tree pods (Jetan et al., 2012); assessment of *Grewia oppositifolia* leaves (Khan et al., 2012); supplementation with Leucaena and *Acacia mangium* wild foliages (Traiyakun et al., 2012), and the feeding of biscuits (Retnani, 2012). This lack of relevance does not promote progress. The type of projects undertaken in feeding and nutrition are given below.

Examples of projects in feeding and nutrition

• Supplementary feeding with local crop residues and by-products

• Supplementary feeding with leguminous tree fodders

• Nutrient requirements

• Treatment and feeding of crop residues

• Meat and milk response tests

• Balanced diets for growth and milk production

• Fodder production and grazing management

• Mineral supplementation

• Integration with tree crops

• Evaluation of rangeland grazing

The value of much of relevant research can only be reflected in holistic on-farm research and development activities, in target areas where interdisciplinary and team efforts become very important. To a large extent, well developed projects that are coupled with appropriate component technology application and have community-based participation will result in clear impact and sustainable animal agriculture that directly benefit the farmers.

FOCUS ON RAINFED AREAS

The general neglect and bypass by most national programmes and donor agencies of the development of small farms is a sad reflection of our times. The estimated total number of small farms 4,700 million (below two hectares of land), of which 87% or 348 million farms and about two million resource-poor are found in Asia. Many of these farms are models of efficiency in natural resource management and low resource input systems, producing food for subsistence and occasionally for income. No hard data exists on the volume and extent of food produced on these small farms, but it is widely believed that this is of the order of 50%. To suggest therefore that small farms are not competitive, are inefficient and will disappear in time, is unacceptable and irrational. Development must therefore hasten to give very high priority to their development to increase agricultural productivity, food security and overcome poverty. Massive investments and appropriate policy is required for community-based programmes to address and enhance the plight of small farms, small farmers.

Priority attention needs to be given to the development of rainfed areas. The justification for targeting the rainfed areas is related to the twin reasons of inadequate availability of arable land and the need to increase agricultural productivity to meet the projected human needs. Inadequacy of arable land is associated with the following reasons inter alia: demand for agricultural land to meet human needs, e.g. housing, recreation and industrialisation; expansion of crop production to ceiling levels; in Malaysia, expansion of oil palm areas into high potential arable land; and increased urbanisation and use of arable land.

The extent of the rainfed areas in Asia is considerable (ADB, 1989). The rainfed areas involve marginal/less

Table 2. Proportion of poor livestock keepers within production system by region (%) (Thornton et al., 2002)

Production system	Developing countries	Sub-Saharan Africa	N. Africa and Near East	South Asia	East and S.E. Asia	Latin America and Caribbean
Grassland-based systems	7.1	13.1	14.3	2.5	1. 8	9.0
Mixed rainfed systems	66.0	77.9	56.6	60.1	59.3	67.9
Mixed irrigated systems	18.5	0.4	16.9	33.7	29.0	3.6
Landless	8.4	8.5	12.1	3.7	9.9	19.5

favoured+arid lands+forests and woodlands, and accounted for 83.1% of agricultural lands compared to 16.6% favoured land. Marginal and arid lands alone constituted 48.5% of the total area. Additionally, about 63% of the rural population was found in the former compared to only 37% in the favoured areas.

The ownership of animals by poor people is especially significant in the harsher and more difficult environments. In these situations animals often sustain livelihoods and survival. Table 2 presents the extent of poor livestock keepers by production system and region, and several observations are relevant. Within these systems and within-region, South Asia and South East and East Asia accounted for a 59 to 60% proportion of total poor livestock keepers. Mixed irrigated systems were the next highest, with a 29 to 33.7% proportion. The higher number of poor livestock keepers in the mixed farming systems in rainfed areas is consistent with the higher proportion of the rural poor found in the combined marginal, arid lands, forests and woodlands (Table 2).

Animal production involves zero grazing practices and extensive systems that are associated with resource-poor nomads, transhumants or agricultural labourers and seasonal migrations with small ruminants, cattle and camels. The movements are annual cycles that are triggered by reduced feed and water supplies, inadequate market opportunities and loss minimising strategies (Devendra, 1998). This is also a way of life for the poor and the ownership of the animals enables survival and also food and financial security.

Within Asia, the largest numbers of poor people are found in India. The country has reduced absolute poverty, from about 55% in the 1970's to about 35% today. The percentage of rural poor out of the total poor is about 79%, and as a consequence of which the major focus is on this rural sector and ways to stimulate agricultural growth to overcome persistent poverty. Associated with this situation however, is the very high infant mortality rate, and high percentage of births not surviving to age 40 yrs and underweight children under-age five years (Human Development Report, 2001).

Poverty is a major issue of concern since the rainfed areas also have large populations of the poorest of the poor, in which the vast majority live below the US $1/d yardstick. It is estimated that livestock contributes to 70% or about 987 millions of the rural poor worldwide (Livestock in Development, 1999). ILRI (2006) has estimated that 35% of these poor livestock keepers live in South Asia, about 30% in Sub-Saharan Africa, about 15% in East and South East Asia, and the remainder are distributed over Latin America, West Asia and North Africa, and Europe and Central Asia.

The presence of relatively large populations of ruminants, including goats (TAC, 1992) in these areas, and also large livestock farmers in these areas, is reflective of the value and multifunctional contribution of goats. For these reasons, it is suggested that expanding goat production in these areas represents the entry point for development of rainfed areas. Development agents are therefore encouraged to promote this concept in a wider scale.

EFFECTS OF CLIMATE CHANGE

The effects of climate change are now becoming increasingly serious. The core issue is uncertainty of climate and the biophysical environment. Table 3 summarises the effects of climate change on land use and livelihood systems. The effects are serious and wide ranging, and cause inter alia reduced soil moisture, expansion of semi-arid and arid AEZs, increased droughts, increased rangelands, increased woody encroachment, desertification, increased overstocking of heat tolerant animals, e.g. goats especially in the rangelands with resultant soil degradation, reduced biodiversity and effects on the ecosystems. The resultant trend will be a shift out of agriculture.

Crop production will be seriously affected by climate change involving both annual and perennial crops. Cash crops, which are so important for income and the stability of households, will either have reduced yields or not grown at all as is already happening with successive droughts. It has been reported (Haji Basir Ismail, 2005) that rice yields decreased by 10% for every 1°C increase in temperature. The ADB (2009) also reviewed the effects of temperature rise on crop yields and has projected in South East Asia (Indonesia, Philippines, Thailand and Vietnam), there will be rice yield falls by about 50% in 2100 relative to the 1990 level (Table 3).

With animals, the effects of climate change on productivity will depend on the resilience of animal

Table 3. Effects of climate change on land use and livelihood systems of the poor (Devendra, 2012a)

Land use systems	Livelihood systems of the poor*
Reduced soil moisture	Reduced food and nutritional security Availability Access Utilisation , and Food systems stability FAO (2008)
Problems with agricultural water management	
Changes in soils due to modification of water balance	Increased risk of poverty and hunger
Ecosystems changes: genetic resources and biodiversity	Increased vulnerability
Expansion of semi-arid and arid AEZs	Inability to adapt to heat stress
Increased droughts	Inability to sustain animal production as a key feature of rural livelihoods
Increased rangelands	Reduced products and services from agricultural biodiversity
Woody encroachment	Increased susceptibility to diseases
Desertification	Reduced productivity
Increased overstocking of heat tolerant animals e.g. goats especially in the rangelands with resultant soil degradation	Reduced income
Alter the suitability of land to grow crops	Reduced self-reliance
Increased salinisation	Increased urban migration
Reduced biodiversity	
Species adaptation and distribution	
Shift out of agriculture	

* Includes the landless.

Table 4. Major Issues In animal production that will be affected by climate change impacts (Devendra, 2112a)

Major issue	Potential climate change impacts	Opportunities for R and D
Heat stress	• Physiology • Metabolism • Reduced feed intake • Reduced reproduction • Increased mortality • Low productivity • Unsustainable production systems • Reduced multifunctionality	• Adaptation • Feed efficiency • Measures to increase intake • Supplementation • Improved management
Feed resources (Forages, crop residues, AIBP and NCFR)*	• Reduced quantities • Poorer nutritional quality • More fibrous • Decreased palatability	• Use more heat tolerant plants • Food-feed systems • Use of multipurpose tree legumes • Conservation
Land use systems	• Shift to dry land agriculture • Droughts • Water scarcity • Diversification of agriculture • Sustainability	• Heat tolerant plants and animals • Emphasis on rainfed agriculture • Maximising feed supply
Animal species and breeds	• Adaptation • Possible reduction in size • Loss of biodiversity • Migratory systems • Uncontrolled and overstocking can cause environmental degradation	• Dynamics of nomadic and transhumant systems • Ensuring choice for AEZ • Understanding interactions with the environment • Improving Vulnerability and survival of the poor and their animals
GHG emissions enteric fermentation and manure, producing global warming	• Reduced crop growth and animal productivity • Poor C sequestration	• Improved use of grasses, legumes and agronomic practices • Use of dietary nitrates to reduce CH_4 • Intensification
Integrated NRM and holistic systems*	• R and D capacity	• Interdisciplinarity • Use of systems perspectives • Advantage of shade in Plantations
Semi-arid and arid AEZs including rangelands	• Reduced feeds • Overstocking • Environmental damage	• Control of numbers • Use of multipurpose leguminous trees • Improved management

*AIBP = Agro-Industrial By-Products; NCFR = Non-Conventional Feed Resources; NRM = Natural Resource Management.

production systems. The extent of adaptation will be especially important in the future. Tropical climates with their high temperatures and humidity affect behaviour and induce metabolic changes that result in reduced feed intake and therefore productivity.

Table 4 summarises the situation with reference to types of key issues e.g. heat stress, feed resources, climate change impact and opportunities for R and D. The information that is presented is not exhaustive but rather the range of issues involved was attempted to be captured in a comprehensive way. High temperatures and reduced feed intake significantly influenced productivity, and in the tropics, this may be between half and one-third of the potential of modern cow breeds (Parsons et al., 2001). Cow fertility, fitness and longevity may also be reduced (King et al., 2006). Heat waves have also caused substantial mortality in animals in the USA and northern Europe (Sirohi and Michaeltowa, 2007). Moran (2005) has reported that in dairy cows the initial symptoms are behavioural and then physiological. Within sheds, these were observed: refusal to lie down, reduced feed intake, agitation and restlessness, reduced or halted rumination; open mouthed laboured breathing; excessive salivation; inability to move; collapse, convulsion and coma; physiological failure and death.

ELEMENTS OF DEVELOPMENT STRATEGY

Well formulated and targeted R and D programmes, including the experience of the Green revolution, can result in significant outputs in productivity. Affirmative action is also used to resolve prevailing deterrent factors such as waning agriculture, constraints to decreasing agricultural productivity, the awesome dilemma of inadequacy of food supplies to meet human requirements-now and projected, inadequate application of appropriate technology and poor delivery systems to farmers. Four factors are central to ensure success of the strategy and are as follows:

Resolution of priority constraints using systems perspectives

A vigorous agenda for sustainable agricultural production in the future will require increased commitment to a few key elements: focus on target priority AEZs, community-based interdisciplinary R and D, and application of farming systems perspectives in whole-farm situations. The framework for R and D will address the priority issues within the evolving scenarios such as nutrient flows, overgrazing, year round feeding systems and zoonoses. Specific problems cannot be resolved by a single discipline alone, which has been a major weakness of many research programmes involved with NRM in the past.

Sustainable intensification of productivity-enhancing technology application and impacts

Well formulated and targeted R and D programmes, including the experience of the "Green revolution", can result in significant outputs in productivity. Affirmative action is also used to resolve prevailing deterrent factors such as waning agriculture, constraints to decreasing agricultural productivity, the awesome dilemma of inadequacy of food supplies to meet human requirements - now and projected, inadequate application of appropriate technology and poor delivery systems to farmers.

A good example of an important opportunity for intensification and increasing productivity from ruminants in the future concerns the need for more intensive utilisation of crop residues. Straws have a number of uses; and current feeding practices to ruminants are without appreciation of production responses that could be achieved with treatment and 7 supplementation. Cereal straws need targeting to implement the known advances in ammonia treatment to improve nutritive value, as well as strategies to supplements to increase straw use by ruminants. The scientific basis of feeding supplements to ruminants fed on poor quality forages has been discussed in a number of papers (see for e.g Leng, 2004; Devendra, 2010a) and the efficient use of such feeds is a major way to increase animal proteins for human consumption in the future. There is no reason why these technologies cannot be put to intensive use and adopted more widely in Asia.

Increasing productivity in successful projects depends to a very large extent on the application of technology options from research that serves development. The potentially important productivity-enhancing technology options have already been reviewed and is given below(Devendra, 2010b.). However, for illustrative purposes the first on the list is described also emphasising potential replication in Sub-Saharan Africa and Latin America. There exist a number of proven and potentially important productivity-enhancing technologies, the use of which can significantly increase productivity in animals. These include *inter alia*:

i) Three-strata forage system
ii) Food-feed inter-cropping
iii) Integration of ruminants with tree crops
iv) Effective utilisation of crop by- products and non-conventional feed resources
v) Strategic supplementation
vi) Rice-vegetable-ducks-fish integration
vii) Sloping agriculture land technology
viii) Effective use of local feed resources: large scale beef production using ammoniated rice straw and cottonseed cake (Plate 6).

Defining a policy framework

The implementation of the R and D activities for coping with the effects of climate change in agriculture will also

Plate 6. Among the potentially important "improver breeds", the Jamnapari from India is an example of an outstanding, breed. Much more use cab = an can be made of "improver" breeds.

need realistic policy elements to ensure the success of a pragmatic agenda. These policy requirements appropriate for agriculture are reflected in the following:

• Affirmation official policy to address waning agriculture, its revitalisation, integrated NRM and the effects of climate change priority for food security and increased self-reliance without compromising the environment

• Priority for concerted R and D of rainfed agriculture and small farm systems

• Increased focus on the development of marginal and fragile lands

• Improved water efficiency for cropping systems and land use systems

• Priority for pro-poor community-based activities that can adapt to climate change

• Promotion of ways and means to enhance C sequestration and reduce emissions of GHG e.g. development of sustainable integrated tree crops-ruminant systems

• Building R and D capacity and application of systems perspectives to deal with climate change

• Increase substantial investments in agriculture to promote greater engagement and productivity,

• Promote public-private sector partnerships to address agricultural development in the context of climate change.

Vigorous delivery of yield - increasing technologies and strengthening research-extension - farmer linkages

Over the last few decades, significant R and D activities in many developing countries have resulted in numerous yield-inducing technologies particularly in crop production, aquaculture and less so with animal production. Good examples are the different varieties of high yielding rice, improved use of the water resources for irrigating rice fields, and significant improvements in the efficiency of feed conversion in poultry and pig production. It is not proposed to review these, but rather look into why there has been so poor uptake of these technology and hence low agricultural productivity.

The main reason for this situation appears to lie with the mechanisms of technology delivery application and adoption. In many developing countries, there are meanings of the term extension, as well as systems and structures that deal with it. Currently, the traditional model continues to be used: extension is viewed in numerous ways, from approaches to help farmers to increase production, to marketing arrangements. This has in turn led to scientists to consider research mainly in terms of technological merits and the publication of results, and leave the diffusion of the results and practicalities to others. That view is no longer realistic and acceptable, for several reasons such as inadequate services, inadequate technical know how, lack of understanding of systems perspectives and participatory methods, and capacity to rapidly respond to farm problems. In recent years extension orientation is being further detracted to include innovative structural, funding and managerial arrangements (Rivera and Sulaiman, 2009).

There is therefore concern about the relevance of these terms to productivity small farms and livelihood of farmers. Research-extension-farmer linkages together with participatory efforts with rural communities help to address problems on the farm, their resolution, and more importantly the adoption of improved technology. There needs to be commitment to this process and investment in effort to promote wide diffusion and adoption of suitable technologies. In this context, it has recently been suggested that the transform of agricultural education and appropriate formal curricular is relevant, that combines strong

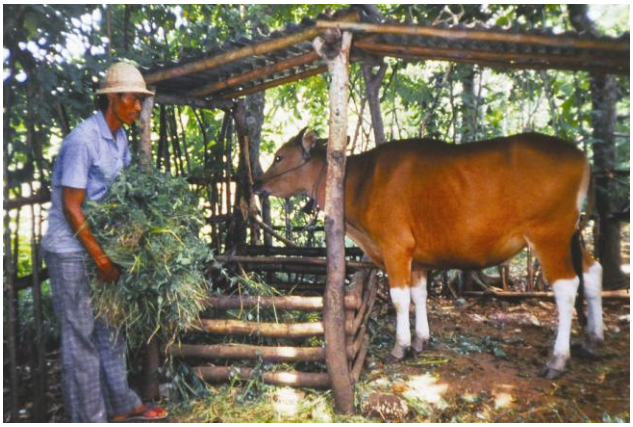

Plate 7. The three strata forage system is an outstanding example of a productivity enhancing technology that integrates cash croping with planting and harvesting forages all year round in a sustainable crop-animal system involving mainly cattle and goats i Bali, Indonesia. Photo shows a farmer feeding forages to fis cow (C. Devendra).

disciplinary orientation, systems perspectives and systems methodologies to enhance the future of animal agriculture. This factor along with opportunities for using major technologies reported from elsewhere in Asia such as food-feed systems, have recently been reviewed (Devendra, 2011). Village cooperatives are an important conduit for the wider adoption of technologies as was seen in 'Operation Flood' and in surveys on milk producing districts in India (Tripati et al., 1995). Non-governments also play a significant role in the use of appropriate technology application.

Rigorous application of systems methodologies

On account of the complex nature of mixed farming or crop - animal systems in Asia, interactions with the environment and now climate change, an understanding of FSR methodologies is essential. The systems approach involves sequentially the following: - site selection, site description and characterisation (diagnosis), planning of on-farm research, on - farm testing and validation of alternatives, diffusion of results and impact assessment.

Systems perspectives, systems approaches and interdisciplinarity are minimal despite the dominant emphasis on mixed farming in Asia, research on crop - animal systems is seldom integrated, and with rare exceptions, very few institutions recognise the importance of training in systems research. As a consequence, the complex and interrelated systems-based problems in crop-animal systems are not addressed in holistic terms this tendency explains why improved productivity from animals in small farm systems is slow to be realized. To a very large extent, the same reasons also apply for the general neglect of the rainfed areas, the inadequate productivity from small farm systems therein, and the contribution from animals. The systems approach requires multi-and interdisciplinary interpretation of the different components of the system and biophysical environment, identified through detailed analyses of the constraints, needs and opportunities. These together ensure that the individual components, interactions and contributions can focus on the whole system are fully addressed.

The systems approach needs to be backed by a few other important requirements:

• Recognition of the importance of interdisciplinary participatory approaches

• Formulation of research programmes that have community-based participation to set a common agenda and create ownership. This should involve the continuum of both production and post-production systems.

• Programmes that are needs-led and have institutional and structural commitment

• Establishment of effective participatory planning, inter-institutional coordination and collaboration, research management, dissemination of information, and resolution of feedback issues

• Long term commitment to achieving impacts

• Education and training in agricultural systems and systems methodologies at various levels.

The methodology

The methodology for systems research is distinct and follows several sequential steps:

i) Site selection
ii) Site description and characterisation (Diagnosis)
iii) Planning of on-farm research
iv) On-farm testing and validation of alternatives.
v) Dissemination of results, and,
vi) Impact assessment.

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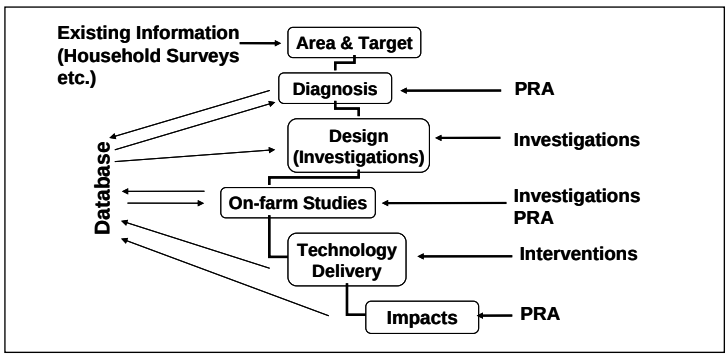

Figure 2. Methodology for farming systems research.

• Long term commitment to achieving impacts
• Training in agricultural systems and systems methodologies at various levels.

Figure 3 illustrates the steps involved in farming systems research.

NETWORKS AND NETWORKING

An important instrument that is essential for the more rapid dissemination of importance of the more potentially valuable information concerns networks. Rapid information flow can also reinforce the wide delivery of knowledge for scaling up and quantum jumps on productivity. Networks are agents for development and have a number of important functions;

• Agents for development
• Adds value to work
• Advances the effectiveness, use and profile of research results
• Enhances the quality of R and D
• Advances the use of research in policy making
• Strengthens the local ownership of research and results
• Forum for information exchange
• Enables members to interact directly
• Self-sustaining in the long run.

A number of R and D networks have been formed over time, and have significantly contributed to improved agricultural production in Asia. These include *inter alia*:

• Asian Farming Systems Research Network (AFSRN)
• Forage Network
• Small Ruminant Production Systems Network (SRUPNA)
• Crop-animal Systems Research Network (CASREN)

The ARFSN was established by the IDRC a cropping systems network in the 1970s with a systems approach to research. It started as a cropping systems network based at the International Rice Research Institute (IRRI). In 1993, the animal component was added to the network to give emphasis to crop-animal systems and also address the totality of farming systems. There were some R and DD 72 sites in nine countries.

Over a period of some 16 years it was very effective in promoting the importance of systems perspectives and systems research methodology, and methodologies relevant to farming systems research. Increased research capacity was apparent in 14 countries in Asia resulting in institutionalisation of crop-animal systems research. Research Institutes were formed in the Philippines and Thailand, and farming systems offices in Bangladesh, Indonesia, Nepal and Pakistan. In India for example, a Cropping Systems Directorate was established involving 16 Universities.

INVESTING IN AGRICULTURE

Investing in agriculture R and D is the key determinant of agricultural growth and improved productivity. This needs major public agricultural research (governments, universities and non-profit agencies), and the private sector as well. A large body of evidence clearly indicates that productivity improvements to investments in agricultural R and D, in which the estimated returns are high, and high enough to justify an even greater investment of public funds (Devendra, 2007). Reversing declining agricultural growth is feasible, and calls for keeping food prices low, and increasing the level of R and D to the extent possible. The

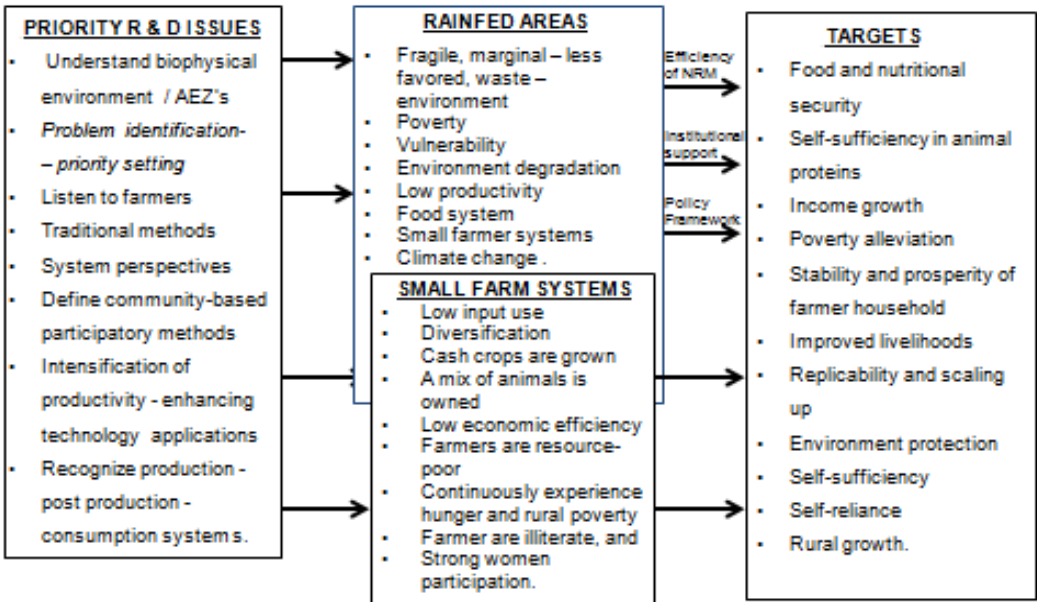

Figure 3. Ruminant as the entry point for the development of rainfed areas.

combined thrust of using problem-solving research results, efficient research-farmer-extension delivery systems for appropriate agro-technologies, backed by sustained investments can impact on demonstrable integrated NRM.

The rationale for neglect and by-passing the LFAs is associated with the following reasons:

• Failure to resolve to reduce poverty, malnutrition and food insecurity
• Increasing evidence of reduced yields, productivity growth and stagnation
• Improved understanding of the potential value and use of available production resources and yield-enhancing new technologies, and
• Potential opportunities to increase food production.

In the light of above, it is quite possible that increased investments in the Flues could have greater impact on poverty, improved livelihoods and the environment. This issue was assessed by IFPRI with reference to agricultural production and poverty alleviation impacts of different types of environments in high and low-potential areas in India (Fan and Hazell , 2000) and China (Fan, Zhang and Zhang, 2000). Table 5 presents the results from China. For every investment made, the highest impact on agricultural production and poverty alleviation was made in rainfed lands, while irrigated areas ranked second or last. Many types of investments in low-potential rainfed lands gave some of the highest production returns and impact on poverty.

The results of these studies in India and China were similar, and provide strong justification for increased investments in the LFUs to alleviate poverty, increased income and rural growth. Intensification is inevitable and will lead to increased agricultural productivity and growth which will improve the alleviation of poverty and vulnerability. The enduring hope in the long term is sustainable agriculture, improved livelihoods and self-reliance (TAC, 1992) (Table 5).

CONCLUSIONS

Efficiency in the use of production resources and cost effectiveness of limited funds are important determinants of ensuring successful projects. That success is in turn influenced by the imperatives of realistic project formulation, application and measurement of impact, notably improved livelihoods of the poor and the alleviation of poverty. Additionally, there is a need to cope with the threats of climate change and potential impacts on animal production, especially on food insecurity and survival. Key potentially important strategies need to be pursued vigorously in interdisciplinary R and D terms to cope with complex interactions with the environment. Mitigate the impacts of climate change. Key themes that merit attention include inter alia as follows:

• Development of the potential value of rainfed areas and improved use of less-favoured areas in pro-poor initiatives
• Breeding, conserving and improved use of indigenous goat genetic resources, and particularly the "improver breeds"
• Identify potentially important means of mitigating the impacts of climate change;
• Wider expansion and benefits of underestimated integrated tree crops-ruminant systems, including stratification and C sequestration.

There is great urgency for R and D to address these and other issues and intensifies the improved and efficient use of the natural resources. Increased investments and institutional commitment are equally necessary for productivity enhancement, reduce poverty in the poor and

Table 5. Marginal returns to infrastructure and technology investments in rural China (Fan, Zhang and Zhang, 2011)

Investment	High potential coastal region	Mid potential central region	Low-potential western region
	---------- Production return in yuan per yuan invested ----------		
R & D	7.33	8.53	9.23
Irrigation	1.40	0.98	0.93
Roads	3.69	6.909	6.71
Education	6.06	8.45	6.20
Electricity	3.67	4.89	3.33
Rural telephone	4.14	8.05	6.57
	---------- Number of people lifted out of poverty per 10,000 yuan invested----------		
R & D	0.97	2.42	14.03
Irrigation	0.15	0.23	1.14
Roads	0.70	2.80	14.60
Education	1.79	5.35	21.09
Electricity	0.92	2.64	9.62
Rural telephone	0.98	4.11	17.99

the landless, and support the preservation of the environment.

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