

# Agricultural Engineering Research and Development in Nepal

G B Manandhar

## BACKGROUND

Nepal is a land locked country between India and China with an area of 147,181 sq. km. Nepal is mainly divided into 3 ecological zones; *terai*, hill and mountain which occupy 23.1, 41.7 and 35.2 percent of land area respectively. Terai is the more or less flat land located at the southern strip with elevation range 100-300 m including *Churia* range with elevation 150 to 750 m amsl. Hill consists of *Mahabharat* range and lower *Himalaya* foot hills with elevation of 300 to 2600 m. Mountain consists of Himalayan range of 2600 to top of the world. Hence, in the south-north cross section of the country with in a span of 130 to 240 km diverse climatic condition i.e. from sub tropical in south to alpine in north is observed. The average rainfall is 1600 mm with 80 percent occurring in monsoon, which lasts for 4 months (June to September). The country's population as per 2001 census report is 23.1 million with 48.43, 44.28 and 7.29 percent residing in *terai*, hill and mountain respectively. The GNP per capita is US\$ 242.

## AGRICULTURE SCENARIO:

Agriculture is the backbone of national economy, means of livelihood for majority of population, main source of GDP, income and employment opportunities. The agriculture contributes to about 38% to national GDP and provides part and full time employment opportunities to 80% of its population. Due to continuous fragmentation of land, the land holding/ family across Nepal is found to be less than a hectare at present. Moreover average size of parcel is found to be less than 0.3 ha (table 1). Because of fragmentation of land and unavailability of the other employment opportunities in the country majority of farmers in the country are compelled to adopt subsistence agriculture. Due to low investment capacity and lack of infrastructure & market opportunities majority of farmers are adopting traditional technology in their production system.

**Table 1: Ecological zone wise land holding size distribution in Nepal**

	No of Holding	Area of Holding (Ha)	Average land owned / HH	Average no of parcel	Average size of parcel (Ha)
<b>Nepal</b>	<b>298,223</b>	<b>218,707</b>	<b>0.80</b>	<b>3.3</b>	<b>0.24</b>
Mountain	1,586,406	1,038,615	0.74	4	0.18
Hill	1,479,510	1,396,716	0.66	3.2	0.21
Terai	3,364,139	2,654,037	0.96	3.2	0.30

Source : CBS(2001)

Major cereals are rice, maize, wheat and millet of which rice is the main staple food. Sugarcane, oilseeds and potato are categorized as cash crops. Apple, oranges, mango, banana etc are the main fruit crops. Potato, cabbage, cauliflower, beans, tomato, etc. are major vegetables and there is increasing trend of growing vegetables in the areas with road and market facilities. Dairy and poultry have significantly contributed the income generation in the village resulting self-sufficiency in milk and egg production. The area and production trend of major agricultural commodities is given in table 2.

**Table 2: Area & Production of Agricultural Crops***(Area: '000 Ha, Production: '000 M.T.)*

Crops	1981/82		1991/92		2000/01		2003/4	
	Area	Production	Area	Production	Area	Production	Area	Production
<b>Food grain</b>								
Paddy	1297	2560	1412	3223	1560	4216	1559	4455
Maize	475	752	754	1205	825	1484	834	1590
Wheat	400	526	571	779	641	1158	664	1387
Barley	27	23	30	28	28	30	27	30
Millet	122	122	198	229	260	283	258	283
<b>Total</b>	<b>2321</b>	<b>3983</b>	<b>2965</b>	<b>5464</b>	<b>3314</b>	<b>7171</b>	<b>3342</b>	<b>7745</b>
<b>Cash crop</b>								
Sugarcane	25	590	37	1291	59	2212	59	2305
Oilseed	114	79	154	88	188	132	186	132
Tobacco	7	5	7	6	4	4	3	3
Potato	52	321	85	733	129	1314	143	1643
Jute	35	43	15	19	11.3	16.4	11.7	16.8
<b>Total</b>	<b>208</b>	<b>448</b>	<b>261</b>	<b>846</b>	<b>332.3</b>	<b>1466.4</b>	<b>402.7</b>	<b>4099.8</b>
<b>Pulses</b>			261.9	154.54	306.2	243.2	316	265
<b>Fruits</b>				502.00	48.2	487.3	54.1	511
<b>Vegetables</b>			140.5	1128.00	157.2	1653	172.5	1890
<b>Fish</b>					5.9	15.32	6	18
<b>Milk</b>				864		1124		1231
<b>Egg</b>				369		507		575
<b>Meat</b>				147		194		208

*Source : MOAC (2006)***FARM POWER AVAILABILITY:**

Human labor is the main source of power, in Nepalese agriculture. It occupies 44 percent of the total farm power available in the country (Table 3). Next comes the animal power, which occupies 28 percent of total farm power availability. The available mechanical power in the country is only 28 percent. The mechanical power is mainly used in terai plains.

Pariyar (1992,1995) computed the gross physical energy use in the cultivation of paddy, wheat and maize. The study reveals that tillage is the most power intensive operation consuming about 69% of the total energy use in paddy, 40% of total energy use in wheat and 46% of total energy use in maize. Draught animal energy use in tillage of paddy is about 86% of the total. It is estimated that with the current level of energy use and availability of mechanical power, the draught animals require about seven weeks to complete the tillage operations for paddy in the terai. The field studies and various formal/informal interactions with researchers indicate that an optimum time period for tillage ranges from three to four weeks. Although a detailed research is needed on energy use patterns and their effects on crop production, it is observed that there exists an acute energy constraint for the tillage of paddy. The energy constraint results in delayed transplanting and low - cropping intensity that ultimately account for the low productivity of agricultural land in Nepal. As such, in order to enhance the productivity, this energy constraint will have to be overcome by adequately supplementing the draught animals with the use of inanimate energy resources.

**Table 3: Farm Power Available in Nepal.**

Sources of power	Available Power, kw			Percentage of total		
	1981	1991	2001	1981	1991	2001
Agriculturally Active Human Labor (15-59 yrs)	556766	670360	861767	49.4	46.3	44.3
Draught Power (Cattle Oxen, He-buffalo)	479654 <sup>b</sup>	560749 <sup>a</sup>	537645 <sup>***</sup>	42.6	38.7	27.7
Mechanical Power	90707	217983	543965	8.0	15.0	28.0
All Total	1127127	1449092	1943377			

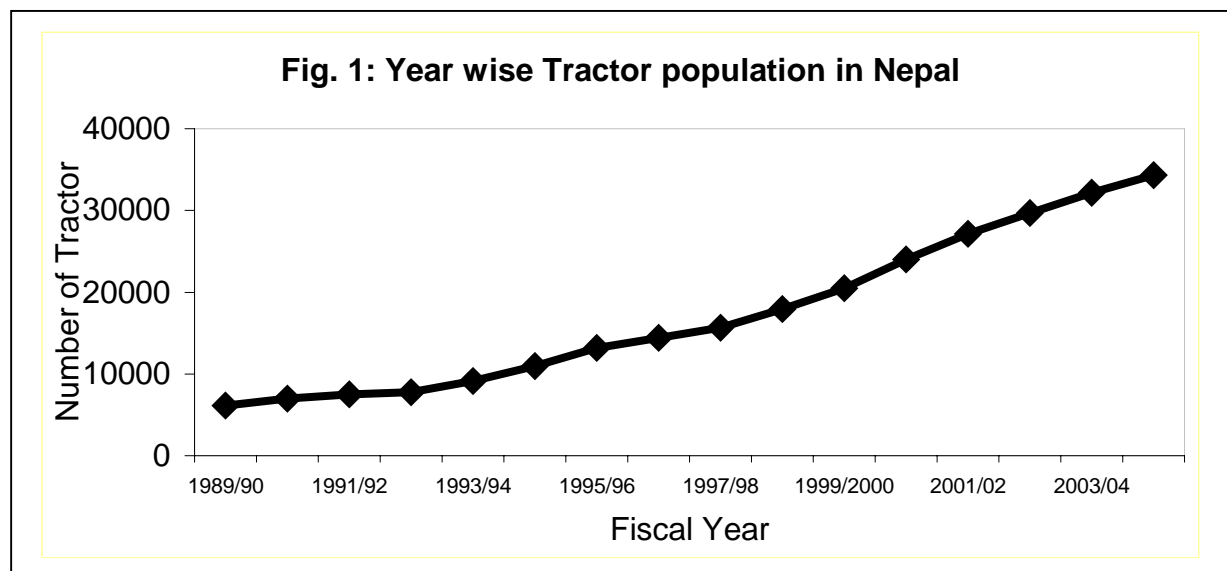
<sup>a</sup> Pariyar & Singh (1994); <sup>b</sup> partly estimated from the data of 1991/92 and based on cattle oxen percentage of 1998/99\*\*\* estimated value from CBS publications

## MECHANIZATION STATUS:

The traditional wooden tools and implements have continued to remain in use in the hills and mountains. There has been some improvement in their design and performance capabilities over time (Pariyar 1991). Due to the lack of physical facilities (viz. road networks and electricity) and cultivation in narrow terraces in hilly areas; hill agriculture is mainly depended upon human and animal power. Hence, hill agriculture needs to be mechanized by using improved hand tools & animal drawn implements. The paddy sheller and polisher and mechanical grinding mills are found to be adopted in majority of villages of terai and hills. However in the mountains, still the milling is found to be performed in local devices such as mortar & pestle, quern and water mills.

In terai also there is a trend towards the use of improved manual tools, e.g. corn sheller, pedal thresher and improved animal-drawn implements, e.g. mouldboard plough, three-tine cultivators, four-disc and six-disc harrows. The pneumatic-tyred animal carts are rapidly replacing the traditional animal carts. This change is taking place mainly due to the scarcity of wood, which is required in large quantities to fabricate the two large wheels of the traditional cart, and also because of an increase in the load-carrying capacity and pulling efficiency of the pneumatic-tired animal cart.

Mechanically powered machines are gradually taking over the power-intensive farm operations (i.e. the farm operations which require high doses of power input but little control e.g. tillage, transport, threshing and lift irrigation) whereas the control-intensive operations (i.e. the operations which require relatively little power but a high degree of control, e.g. transplanting, weeding, harvesting, etc.) are still performed completely by human labor. Tractors and power-tillers are used for tillage and rural transport and to some extent for threshing. Mechanization of tillage is favored because its cost is considerably lower than animal power sources. Mechanically powered pump-sets are becoming popular since the availability of irrigation water has enabled farmers to intensify cropping and grow up to three crops in a year such as two successive paddy crops followed by a wheat crop.



For about last five years, labour is getting scarce during peak periods and their charge is increasing. From time to time, farmers are complaining on increased cost of production and reduction/unexpected fluctuation of price of certain commodities like rice, cardamom, etc. So,

some innovative farmers have imported few combine harvesters for custom hiring. The user farmers are found to be increasingly interested in adopting combine harvester to reduce cost of harvesting.

Number of tractors being registered with the Department of Transport Management is increasing every year. Total number of four & two wheel tractors registered had reached 29662. 4 wheel tractors in the terai and 2 wheel tractors in the valleys have brought revolution in the tillage operation and there is increasing trend on the adoption of tractors in Nepal and the trend of tractor use in agriculture is given in fig. 1. As an impact of increased demonstration and action research on two wheel tractor (2 WT) by Agricultural Engineering Division (AED) & Agricultural Implement Research Center (AIRC) and lack of human and animal labor in peak cultivation season, there has been quantum jump in 2 WT sale about 850 in last year from 200-400/ year.

## RESEARCH NEEDS

Agricultural engineering research needs of different ecological zones are listed below.

### Hills & Mountain

- Drudgery reducing agricultural engineering technologies
- Income generating and employment generating technologies specially, on high value and low volume commodities.
- Promotion of production and small and medium scale agro processing (apple, citrus, herbs, milk, vegetable seed, honey, tea, coffee, ginger, cardamom etc.)
- Appropriate soil and water conservation technologies
- Technologies for food security and nutrient supply in the food system of inhabitants of hills & mountain

### Terai

- Efficient technologies reducing cost of cultivation in agriculture
- Medium/ large scale agro processing technologies and establishment of agro-industries.
- Efficient water management technologies
- Research needs as per the commercial poultry, dairy, vegetable, growers/ entrepreneurs' demand.

## RESEARCH AND DEVELOPMENT (R & D) INSTITUTIONS

The list of agricultural engineering R & D related institutions and their major contribution on the research and development of the technologies are given in table 4.

**Table 4: Agricultural Engineering R & D related institutions in Nepal**

	Institutions	Type	Major Contributions
1	AED & AIRC	Research	Iron Plough, paddy thresher, zero till & minimum till technologies, grain and seed dryers, cardamom dryer, plastic house for vegetable cultivation, solar dryers, small scale processing tech. (corn Sheller, improved quern, millet pearler), Bed planter, manual rice transplanter, drum seeder etc.
2	RECAST	Research	Improved cook stove, solar dryer
3	Agri. Engg. Directorate	Dissemination	Recently established
4	Purbanchal Campus under Institute of Engineering, Dharan	Education	Training Ag. Engg Graduates and research on agri engg. Technologies through student's research

	Institutions	Type	Major Contributions
5	AEPC	Coordinating institution for Renewable energy technologies	<ul style="list-style-type: none"> <li>•Improved cook stove</li> <li>•Biogas</li> <li>•Micro hydro</li> <li>•Solar technologies (Solar PV, dryers etc.)</li> </ul>
6	ADBN	Credit	Major institution involved in financing for tractors, pump sets, agro processing mills etc.
7	NGOS/ Projects		
A	IDE	NGO	Promotion of Micro irrigation & treadle pump
B	REDP	Project	Promotion of Micro Hydro & RET
C	BSP	Project	Promotion of Biogas
D	SIMI	Project	Promotion of Micro Irrigation & Marketing for small holders
E	CRT	NGO	Promotion of ICS & Water mill

**Agricultural Engineering Division (AED)**, under NARC is the major responsible organization for the research and development of farm machinery and agricultural equipment in the country. Apart from R & D in farm machinery and equipments, it is responsible for the development of technologies in irrigation water management, soil conservation, post harvest engineering etc. At present AED is involved in R &D of maize sheller, peanut sheller, hammer mill, wheat thresher, cardamom dryer, solar dryer, seed dryer, zero till seed drills, reapers, rice husk stoves etc. **Agricultural Implement Research Center (AIRC)**, under NARC is also involved in the research & development of agricultural tools and implements. Where as AIRC, Ranighat is involved in R& D of manual rice transplanters, bed planters, zero till seed drills, reapers, drum seeder, bullock drawn seed drills etc. Major contributions of agricultural engineering technologies by AED & AIRC are listed below.

- Improved animal drawn iron plough adopted in terai and increased adoption in valleys in hills.
- Increased use of 2 WT for agricultural purpose
- Increased adoption of AED&AIRC recommended technologies viz. minimum till for wheat, direct seeding for rice, plastic house technology for off season vegetable cultivation, low cost solar dryer, improved corn sheller etc.

**Purbanchal Campus, Dharan** under Institute of Engineering (IOE) have initiated BSc. Agricultural engineering graduate program since 1999. One batch of agricultural engineering graduate (23 nos.) is already produced by Purbanchal Campus, Dharan. Apart from the production of agricultural engineering graduates, it is also involved in agricultural engineering research through student's research program.

**Alternative Energy Promotion Center (AEPC)** is an organization devoted to the development and promotion of renewable and alternative energy technologies in Nepal. The Alternative Energy Promotion Centre (AEPC) was established according to a Cabinet Order, "Alternative Energy Promotion Development Board Formation Order" under the Development Board Act. The institution has an autonomous status under the purview of Ministry of Science and Technology (MOST). AEPC was set up to promote the use of renewable energy technologies to meet the energy needs in rural areas of Nepal. Acting as an intermediary institution between the operational level Non Government Organizations (NGOs)/ private promoters of renewable energy and the policy deciding levels in relevant ministries, AEPC's activities include renewable energy policy formulation and planning and facilitating the implementation of the policies/ plans. Major achievements on the promotion of Renewable energy technologies in Nepal are listed below.

- By July 2005 programme has succeeded in installing 152,373 biogas plants in Nepal.
- Installed more than 1300 micro hydro schemes with capacity of more than 8000 kw.
- 58,131 systems of solar home system with installed capacity of about 2 MW peak.
- Installed more than 150,000 improved cooking stoves (ICS) till July 2005

**International Development Enterprise /Nepal (IDE/N)** is a national branch of IDE international a not-for-profit international development organization registered in Switzerland and headquarter at Denver, Colorado, USA. Guided by the general agreement with His Majesty's Government of Nepal, IDE Nepal has been working since 1993 to reduce rural poverty by promoting the use of low cost micro irrigation technologies. The major achievements made by IDE and collaborating institutions in the promotion of micro irrigation technologies are listed below.

- 80870 treadle pumps have already been installed mainly in Terai.
- 16808 low cost drip and micro irrigation technologies are already been installed in hills for small scale vegetable cultivation.
- A network of 7 treadle pump manufacturers and 3 drip assemblers have been established.

**Centre for Rural Technology, Nepal (CRT/N)** is a professional non-government organization engaged in developing and promoting appropriate/rural technologies effective in meeting the basic needs of the rural communities and improving their life support system. It is mainly involved in the promotion of improved cooks stove and improved water mill.

## **AGRICULTURAL MACHINERY INDUSTRIES**

Blacksmiths are the primary suppliers of manual and animal drawn implement for the small and marginal farmers of the country. It is estimated that more than 85% of tools/implement used by the farmers especially in hilly areas are made/repared by the blacksmiths/rural artisans. So, blacksmiths could play an important role to help in rural mechanization of agriculture in the country. The blacksmiths need training, better tools/equipment and a reliable supply of high quality raw materials to improve the efficiency of their work. Assistance given to enhance the capability of the local blacksmiths to fabricate improved tools and machinery will certainly lead to the benefit of the village, eventually playing an important role in agriculture & rural development through the supply of efficient agricultural tools and machinery.

The government owned Agricultural Tools Factory (ATF) which was established 35 years ago, had been contributing in the production of agricultural hand tools, tractor drawn implements, threshers, pumpsets etc. It was however privatized in the mid nineties according to the HMG policy for privatization, but at present, it is not functioning at all.

There are also several small metal working industries in the terai mainly involved in the production of small tools & implements. Those small metal working industries could not survive simply on the production of agricultural tools and implements. They therefore rely on the manufacture of other non-agriculture related productions also. Even though there is huge demand of agricultural tools and implements in the country, they are not in the position to supply due to the lack of technical capability and financial constraints.

## **ISSUES & CONSTRAINTS:**

The issues and constraints of different agricultural engineering R & D institutions are listed below.

### **Government funded agricultural engineering R & D institutions**

- Lack of funds for research
- Lack of human resource
- Lack of strong extension agents of Ag. Engg. Technologies.
- Private sector in agril. engg. Technologies (manufacturers, fabricators, traders, village artisans etc.) weak and not organized.
- Need of favorable government policies for mechanization and commercialization in agriculture

### **Renewable energy technology promoting institutions**

- Subsidy is a critical component on promotion of Renewable Energy Technologies (RETs)
- Majority of programs are donor funded (SNV, DANIDA, UN etc.)
- Weak Research component (hardware) in the program

### **Micro irrigation promoting institutions**

- The drip system is found to be feasible up to one twentieth of a hectare and there is need of research to develop bigger system.
- The dissemination is found to be in project approach (donor supported) need to be internalized in existing agriculture extension network.

### **Agricultural machinery related industries**

- High cost of raw materials & its availability
- Need of protection from government to agricultural machinery related industries
- Lack of technical capability
- Small scale and not organized

## **MOVING AHEAD FOR COMMERCIALIZATION OF ENGINEERING TECHNOLOGIES IN AGRICULTURE**

In spite of aforementioned issues and constraints the R& D related institutions are moving ahead for the commercialization of the developed technologies in following manner.

### **Government Funded R & D institutions**

- Started lobbying in need of agril mechanization and commercialization in agriculture
- Started collaboration with the fabricators and manufacturers for the commercial production of prototypes (viz. corn sheller, millet pearler, solar dryer etc.)
- Started collaboration with NGOs, Area Research Station (ARS) and other agencies for joint action research program viz, solar dryer, hailstone protection, maize dryer etc.
- Initiated to start the network of local fabricators and manufacturers of agril machinery.

### **Renewable energy technology (RET) promoting institutions**

- AEPC is coordinating and streamlining the RET dissemination activities including quality control of disseminated technologies.
- Private sector key partners in RET dissemination (viz. Micro Hydro manufacturers, Solar Home System fabricators, Biogas companies etc.)
- RET is given due importance in National policy and programs.

- The local government district development committees are also empowered through energy cells in Rural Energy Development Project (REDP) project districts

### **Micro irrigation promoting institutions**

- Started collaboration with Ministry of Agriculture and Co-operatives (MOAC) & Department of Agriculture (DOA) in Small Irrigation and Market Initiative (SIMI) project.
- Attempts for (Value Added Tax) VAT exemption and import duty reduction for agril inputs ongoing.
- Establishment and mobilization of the private sectors viz. fabricators, wholesaler, distributors.
- Agricultural machinery related industries
- Providing service to the farmers by local artisans by manufacturing and repairing traditional hand tools
- Small scale agril machinery manufacturers are manufacturing the small agril machineries viz. threshers, ploughs, solar dryers, milling machineries, tractor and power tiller trailers, feed mixers, feed mills etc. at commercial scale.
- Medium scale manufacturers producing micro hydro mechanical components are organized as micro hydro group to upgrade their skill & technology as well as lobby the government sector for their professional interest.
- Some of the innovative medium scale manufacturers have also come forward to produce dairy equipments viz. chilling vats, boilers, mixers etc. and poultry related equipments locally.

### **EXPECTED SUPPORT FROM APCAEM**

#### ***Research/studies***

- Medium and large scale production of agricultural machinery is not under taken by private sector even after the Government owned Agricultural Tools Factory ceased to function since 1997. There is need of studies to identify specific interventions by HMGN for the motivation of the private sector to come forward in the manufacture of agricultural machinery at different commercial scale of production.
- Concrete policy on agricultural mechanization is lacking in Nepal and hence policy research studies specially related to agricultural mechanization is required.

Technical and financial assistance from APCAEM is expected for such type of research studies

#### ***Capacity building of agro related metal working industries***

To attract the national and multinational investment on the establishment of agro related metal working industries the support from APCAEM is expected in following areas.

- Technology transfer
- Capacity building of the industrialists through exposure visit, expo etc.
- Linkage development for the establishment of national and multinational agro related metal working industries.

Moreover the capacity of local blacksmiths is to be strengthened and enhanced through training and opportunity for the establishment of small workshop to manufacture improved agricultural tools and implements locally.

#### ***Human Resource Development***

As there is lack of trained human resource in research, development, extension and training, external support from APCAEM is expected to strengthen the research, training, extension and educational institutes of Nepal in the field of agricultural engineering.

### ***Strengthening the APCAEM National Institute:***

AED, NARC as a APCAEM National Institute is networking among the agricultural engineering related institutes in Nepal to the extent possible. However due to the lack of resources, it could not play active role to the expected level. Hence the support from APCAEM is expected in following areas to strengthen networking activities in the country.

- Exchange of experts
- Exchange of commercially available successful prototypes (specially animal driven equipment and manually operated equipment and machinery)
- Exchange of information and publications
- Establishment of Farm machinery testing laboratory at AED/NARC
- Skill development training for existing man power

### ***Joint action research project development***

APCAEM could play facilitating role in the development of joint action research projects in the participating countries and seeking donors for financial support. Some of the possible areas for the joint action research and development projects are listed below.

- Mechanization of hill agriculture
- Small scale post harvest technology in fruits and vegetables
- Cottage scale processing of herbs and medicines
- Rain water harvesting
- Integrated watershed management

## **REFERENCES**

- Karki, A.B. (1999).** Status of Agricultural Mechanization Industry in Nepal. National Workshop on agricultural Mechanization in Nepal. June 10-11, 1999. Kathmandu.]
- Manandhar, G.B. and Adhikary, S.K. (1999).** Role of Blacksmiths in Agricultural Mechanization in Nepal. National Workshop on Agricultural Mechanization in Nepal. June 10-11, 1999. Kathmandu.
- Pariyar, M.P. (1991).** Mechanical Technologies for hill Agriculture: An Inventory of Existing Options and Alternatives. International Center for Integrated Mountain Development ,Kathmandu, Nepal.
- Pariyar, M.P. (1992).** Farm Mechanization in Nepal: An Overview. Asian Institute of Technology, Bangkok, Thailand.
- Pariyar, M.P. (1995).** Technical Report on Farm Mechanization, APROSC. Kathmandu, Nepal.
- Pariyar, M.P. and Gajendra Singh (1995)** Farm Mechanization in Nepal. AMA vol. 26, No2.
- Pariyar, M.P. Shrestha, K.B., and Dhakal, N.H. (2001).** Baseline study on Agricultural Mechanization Needs in Nepal: Rice-Wheat Consortium Paper Series 13. New Delhi 110 012, India: Rice-Wheat Consortium for the Indo-Gangetic Plains.
- Pudasaini, S P (1976)** Resource Productivity, Income and Employment in Traditional and Mechanical Farming of Bara District, Nepal. MSc. Thesis, UPLB, Los Banos, the Philippines
- Statistical Pocket Book (2005)** HMG, NPC Secretariat Central Bureau of Statistics.