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# Contribution of agroforestry in farmers' livelihood and its impact on natural forest in northern areas of Pakistan

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**Agri-silicultural system is in vogue for livelihood under prevailing biophysical limitations of the environment in northern areas of Pakistan. Therefore, to make the farmers realise the significance of agroforestry system and to analyse its income, agro ecological effect on agroforestry income of farmers a study was carried out in two villages of two different agro ecological zones of northern areas in Pakistan; Jalalabad and Bagrot valley. A total number of 120 households were randomly selected for survey and data collection. The study revealed that there was significant difference in agroforestry income in the two agro ecological zones. The double cropping zone has more agroforestry income when compared with the single cropping zone. The agroforestry income and cultivated land had linear relationship such that with the increase of farm size, agroforestry income increased. It was observed that, agroforestry increased the production of tree components on farmland and minimised the dependency on natural forest for firewood and timber.**

**Key words:** Agroforestry income, agro ecological zones, double cropping area, farm size, single cropping area.

## INTRODUCTION

Forest degradation is among most severe environmental issues; particularly in developing countries where the main part of the population who lives in rural areas relies on the natural resources like forests. In Pakistan, the environmental factors are unfavourable to natural regeneration of the forest (Siddiqui, 1996). In addition, the burgeoning population is causing human pressure on natural forest. According to the national agricultural commission of Pakistan, out of ideally 25% forest area, only 5% is presently achievable (GOP, 1988). Under such conditions where forest cover is too low, it is not possible to maintain balance economy and environmental conditions, then, agroforestry is an option for increasing forest cover and farm income (Akber et al., 2000; Neupa and Thapa, 2001).

In the Trans-Himalayas part of Pakistan, fragile nature of the mountain and subsistence nature of the farming increase the risk and vulnerability of the farmers. The physical limitations, transportation difficulties, low productivity and agro ecological constraint, are the main problems in the farming system of the area (Denholm, 1991). Trees in the agroforestry system play important role in the protection of the fragile mountain environment (Thapa and Weber, 1993). The production of fuel wood and timber from agroforestry reduces the illegal cutting from the natural forest (Murnait and Garrity, 2001) and increases the option of alternatives of fuel wood and timber through increasing farm income. Agroforestry has contributed both to the productivity and sustainability of farming systems (Raintree, 1986) because woody perennials are

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more able to withstand against the adverse conditions than crops (Bentley, 1993). Research in the country and in the many parts of the world showed that the overall increase in productivity of agroforestry is greater than the possible losses by negative effects (Gohar, 1994; Urrea, 1995).

The traditional agroforestry is an old practice in the northern areas of Pakistan (World Bank, 1990) but the quantitative information about traditional agroforestry is limited (Maikhuri et al., 2000). Most of the agroforestry research has dealt with biophysical factors of the systems whereas the economic value of agroforestry products has not been quantified to assess the contribution of agroforestry at farm level (Naire, 1993). The agroecological zones influence the farm productivity. In northern areas of Pakistan, the agroecological zones are based on growing period (Higgins and Kassam, 1981). The growing periods depend on the temperature and the temperature is a function of altitude (Conway, 1987). In these areas, the major agroecological zones are divided into three zones namely double cropping, transitional and single cropping zones. Two sequential crops can be grown in double cropping area in one year. The growing period in the double cropping area ranges from 325 to 338 days and the altitude is below 2010 meters (Conway, 1987).

The purpose of this study is to investigate the contribution of the agroforestry in farmers' livelihood under different agroecological zones and its effect on natural forest conservation.

## MATERIALS AND METHODS

### Study area

The study was conducted in Bagrot and Jalalabad situated in northern areas of Pakistan. Bagrot is located at latitude 36°01′ and longitude 74°33′ and average elevation is 2470 m. Jalalabad is located at 35°51′ latitude and 74°29′ longitude and is situated on the average elevation of 1360 m MSL.

In general, northern areas are placed in dry continental climate under the climatic regions of Pakistan (Athar, 2005). Climatic variations are influenced by altitudinal differences. There is significant variation in temperature and precipitation imposed by altitude and topography. According to Mian (1985), the places which have elevation between 2100 and 3300 m like Bagrot valley (2470 m), receive snow during the winter. The upper limit of agriculture in Bagrot is 2900 m where the temperature during the winter is -12°C and during the summer, is 30°C (Cremer, 1992). The average rainfall is 100 to 200 mm. The potential evaporation is higher than the sum of total precipitation therefore, irrigation is necessary through out the summer in both areas (Cremer, 1992). Bagrot is a narrow valley with active geological erosion. Landforms consist of alluvial fans and moraine deposits. Landform of Jalalabad consists of alluvial fans and river terraces.

In the study area, peoples' economy depends upon farm income. More or less, each and every household has land for farming and about 78% of the people depend on farming for their livelihood. The main sources of farm income in Bagrot and Jalalabad are cereals, potatoes, vegetables, fruits, wood, fodder and livestock. Cereals are used mainly for their own consumption while they meet their other expenses by selling vegetables, fruits, wood and live-stock.

The sample was selected on the basis of agroecological zone because these zones have strong influence on the farm income and cost. Therefore, the study area was stratified into two zones, double cropping zone and single cropping zone. Jalalabad was selected for double cropping zone where two sequential cereal crops are grown and Bagrot was selected for single cropping zone where only one single cereal crop can be grown annually.

The sample size was based upon the variation within the population and on the desired level of confidence. Keeping in view confidence level, time and resources available, 120 households were selected randomly from the study area (80 households from Jalalabad and 40 households from Bagrot, because Jalalabad is a large area as compared to Bagrot). The required data were collected by conducting field visits and asking questions from pre-designed questionnaire.

### Variables

#### Independent variables

The independent variables include cultivated land area material inputs (seed, fertilizer and plants) and operational cost (Machinery and labour, including family labour).

#### Dependent variables

The dependent variable includes the agroforestry income (annual crops and tree components).

### Data analysis

The data obtained were analyzed through descriptive statistics and regression analysis with the help of Microsoft excel and Minitab. Two sample t-tests were used to compare the agroforestry income in two selected sites, Bagrot and Jalalabad. Both simple linear and multiple regression analyses were employed to assess the factors, which affect the agroforestry income:

$$Y = a + b_1 x_1 + b_2 x_2 + b_3 x_3$$

Where, Y, agroforestry income; a, intercept; $X_1$, cultivated land; $X_2$, material cost (seed + fertilizer+ seedlings); $X_3$, operational cost (labour and machinery). R-sq. the coefficient of determination is used for assessing the model. Higher value of R-sq. denotes the larger proportion of observed variations in the dependent variables explained by independent variables. The significance of relationship between dependent and independent variables was indicated by p-value. If p-value is smaller than the significance level, then the relationship will be significant.

### Farm economic analysis

To provide the economic justification, farm economic analysis of agroforestry was adopted. For this purpose, all outputs and inputs were analysed to compare the costs and revenues

### Output estimation

The output of the farm included crops (cereals and legumes), fodder,

**Table 1.** Land distributions for different annual crops.

| Annual crop | Average household land allocation for different crops in the study sites | | | |
|---|---|---|---|---|
| | Bagrot (n = 40) | | Jalalabad (n = 80) | |
| | Area (ha) | % | Area (ha) | % |
| W heat | 0.27 | 56 | 0.48 | 78 |
| Potatoes | 0.15 | 31 | 0.03 | 5 |
| Vegetables | 0.015 | 3 | 0.025 | 4 |
| Others | 0.05 | 10 | 0.08 | 13 |
| Total | 0.485 | 100 | 0.615 | 100 |

fuel wood, grasses, poles, fruits, vegetables, timber and crop residues were converted into monetary value by multiplying the farm gate prices. The farm gate price was lower than market price.

### Inputs estimation

The inputs included material and operational inputs. The operational cost included human and animal labour and the machinery that was used for land preparation, ploughing, planting, transplanting, weeding, pruning application of fertilizer, harvesting and threshing. The estimation of the labour costs was based on the local wages. The wages of male and female labour in the study area were UD$1.66 per day (1 US$ = 60 PKR (Pakistani rupee) during 2004), but paid female labour is not very common. The tractor charges for threshing and ploughing were US$5 per hour. The material was estimated according to local price. For farmyard manure, price was US$0.5 per trolley or donkey load weighed about 60 to 80 kg.

## RESULTS

### Farm characteristics

In the study area, farming was entirely dependent on irrigation system. The household average cultivated land was 0.5 ha in Bagrot and 0.6 ha in Jalalabad. Wheat, corn, barley, potatoes and vegetables are grown as annual crops. About 78% of the cultivated land was allocated for wheat in Jalalabad. Corn was cultivated on the same land after harvesting the wheat in the double cropping area (Jalalabad), while in Bagrot, 56% of the cultivated land was under wheat and 31% of the land was allocated for potatoes, because potatoes are cultivated for commercial purpose in Bagrot. Potatoes were grown in Jalalabad on 5% of the cultivated land for home consumption only (Table 1).

The agroforestry in the study area composed of a multi-storey structure. The upper layer was dominated by *Populus* spp. including *Populus nigra, Populus alba, Populus deltoides* and *Populus euamericana*. The sub stories comprised of walnuts *(Juglans regia),* Russian olive (*Eleagnus* spp.*)*, Mulberry *(Morus alba),* willow *(Salix* spp.*)* stone fruits *(Prunus sp., Pyrus* spp.*)* and the lowest woody strata was formed by pomegranate. The annual crops (wheat, corn, barley, potatoes and vege-

tables) and perennial fodder forages were grown with the combination of earlier mentioned woody perennials.

### Cropping pattern

Different planting patterns were found in both sites. Most of the perennial woody plants (trees and shrubs) were planted along the field boundaries in Jalalabad. The most frequent species in the border planting were poplar Russian olive, pomegranate and mulberry. Some fruit orchards were planted in rows in which fruit trees such as cherry and apples were intercropped with cere-als. Row planting was a new technology in the area. Farmers traditionally planted trees either in boundaries of the fields or scattered in the field. The trees of apricot and walnut were found as scattered planting.

The planting pattern was different in Bagrot than in Jalalabad. Trees were planted in home gardens. There was no boundary planting and the trees were found in corners on the fields in form of groves. Scattered planting was very common. The fruit trees found in home gardens were apricot, apple, pears and mulberry.

The fruit trees like cherry, persimmon, apples and pears were found closer to farmers' residences. Farmers preferred these species due to their fruit value. Almost 25 perennial woody species were found in agroforestry. Farmers obtained fuel wood, fruit, timber and fodder from these species. *P. nigra* was the most preferred timber species in agroforestry while apricot, mulberry and Russian olive were planted for the fuel wood.

### Contribution of the agroforestry income

In both areas, the agroforestry income was analyzed by two sample t-tests. The analysis showed that the agroforestry net income in Bagrot was US$549.33. The income from annuals crops and trees accounted for about 77% (US$422.58) and 23% (US$125.98) of the agroforestry net income, respectively. In Jalalabad, net agroforestry income was US$835.93. The income from annual crops was 58% of the total net income and the income from the trees was 42% of the total net income

**Table 2.** Comparison of agroforestry income in Bagrot and Jalalabad.

| Type of crops | Bagrot (n = 40) | | Jalalabad (n = 80) | | Total (n = 120) | |
|---|---|---|---|---|---|---|
| | US$ | Percent | US$ | Percent | US$ | Percent |
| **Annual crops** | | | | | | |
| Gross income | 721.3 | 81.5 | 865.85 | 68 | 817.67 | 72 |
| Expenditure | 298.72 | 88.5 | 378.53 | 87.6 | 351.93 | 88 |
| Net income | 422.58 | 77 | 487.32 | 58 | 465.73 | 63 |
| **Tree crops** | | | | | | |
| Gross income | 164.78 | 18.5 | 402.07 | 32 | 322.97 | 28 |
| Expenditure | 38.817 | 11.5 | 53.43 | 12.4 | 48.57 | 12 |
| Net income | 125.98 | 23 | 348.62 | 42 | 274.4 | 37 |
| **Totals** | | | | | | |
| Gross income | 885.97 | 100 | 1267.9 | 100 | 1140.6 | 100 |
| Expenditure | 337.5 | 100 | 431.93 | 100 | 400.48 | 100 |
| Net income | 548.45 | 100 | 835.93 | 100 | 740.15 | 100 |

**Table 3.** The mean expenditure for inputs.

| Inputs | Jalalabad (n = 80) | | Bagrot (n = 40) | |
|---|---|---|---|---|
| | Amount (US$) | % | Amount (US$). | % |
| Seed | 36.9 | 9 | 75.95 | 22 |
| Plants | 7.7666 | 2 | 3.33 | 1 |
| Chemical. Fertilizer FYM | 169.18 | 39 | 87.38 | 26 |
| Operational cost | 218.13 | 50 | 170.87 | 51 |
| Total | 431.98 | 100 | 337.53 | 100 |

(Table 2). The expenditure on cereals in agroforestry was almost the same in the both areas. The analysis of expenditure showed that. 88% of the total agroforestry expenditure incurred for annuals and 12% of expenditure for the tree component. In other words, the expenditure 46% of the total income was incurred from annuals and only 15% of the total income was from the tree components.

**Material inputs**

The total cost incurred on seed was 22% (US$5.95) of the total expenditure in Bagrot, while in Jalalabad the cost was 9% (US$36.9). The cost of chemical fertilizer and farmyard manure incurred was 39% (US$169.18) as the total expenditure in Jalalabad and 26% (US$89.05) in Bagrot.

**Operational input**

The operational cost included the labour and machinery cost incurred in agroforestry. The operational cost of agroforestry was 51% of the total expenditure in Bagrot and it was 50% of the total expenditure in Jalalabad

(Table 3).

**Outputs**

The study showed that sources of farm income are not similar in the two different agroecological zones. The agroecological effect was observed on the income from agroforestry outputs such as cereals, potatoes, vegetables, fruits, firewood, timber and fodder. In the study area, the cereals comprised of wheat, corn and barley. The contribution of the cereals was found different in the two zones. In Jalalabad, cereal crops contributed 46% (US$372.13) of the agroforestry income, while in Bagrot the contribution was only 28% (US$ 58.8). Fruit is the main income generating factor from trees. In both zones, the income from fruit was 21% of their farm income. Firewood contributed 10% (US$114.85) of the farm income in Jalalabad and 2% (US$ 13.81) of the farm income in Bagrot. In Jalalabad, timber made 3% (US$28.9) of the farm income, whereas, in Bagrot its contribution was only 0.5% (US$ 2.85) as provided in Table 4.

Potatoes were grown as cash crop for commercial purpose in Bagrot and covered 31% of the cultivated land and contributed 35% of the total agroforestry income. In

**Table 4.** Contribution to income from agroforestry outputs.

| Output | Bagrot | | Jalalabad | | P-value | T-value | df |
|---|---|---|---|---|---|---|---|
| | Amount (US$) | % | Amount (US$). | % | | | |
| Cereals | 158.8 | 28 | 372.1333 | 46 | 0.000 | -6.33 | 109 |
| Potatoes | 200.25 | 35 | 38.63333 | 4 | 0.000 | 4.95 | 50 |
| Vegetable | 63.53333 | 11 | 76.55 | 10 | 0.278 | -1.09 | 65 |
| Fruit | 100.9167 | 21 | 181.4667 | 21 | 0.001 | -3.45 | 117 |
| Fuel wood | 13.81667 | 3 | 114.85 | 14 | 0.000 | -8.14 | 89 |
| Fodder | 8.4 | 1.5 | 22.5 | 3 | 0.000 | -5.75 | 114 |
| Timber | 2.85 | 0.5 | 29.8 | 2 | 0.002 | -3.22 | 82 |
| Total | 548.5667 | 100 | 835.9333 | 100 | | | |
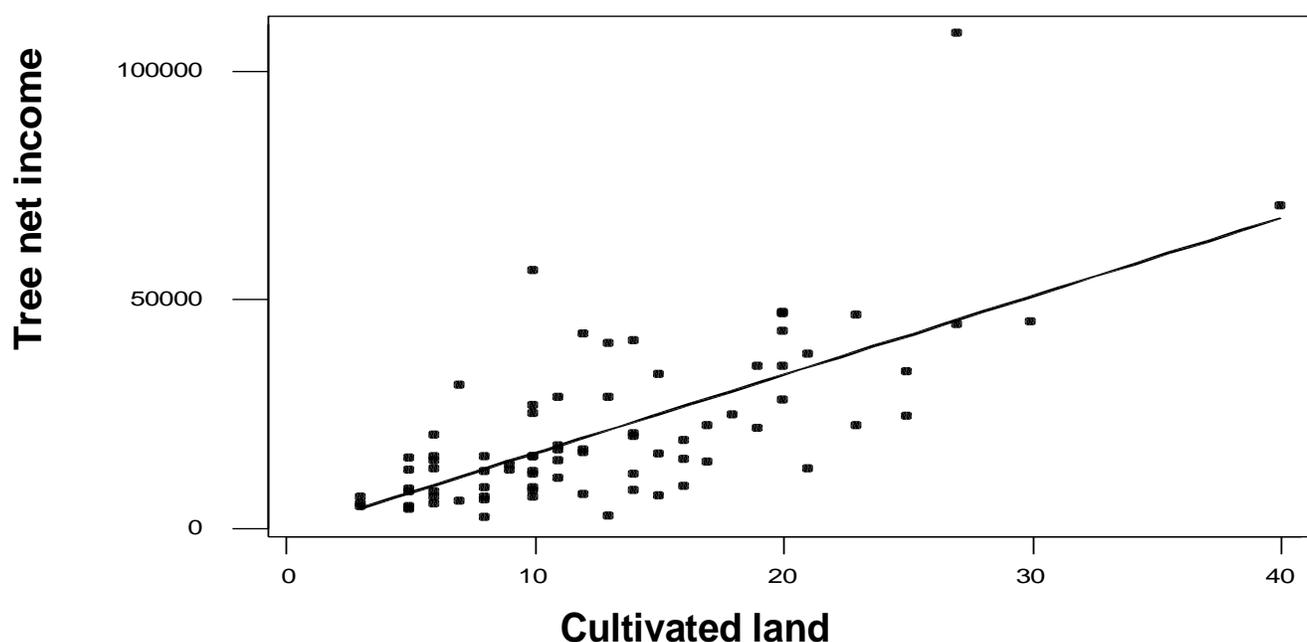


**Figure 1.** Regression analysis of cultivated land and net trees income in Jalalabad. Net tree income = 1061.75 + 1719.00 C.Land; S = 12576.6; R-Sq = 48.4% R-Sq (adj) = 47.6%.

the case of vegetables, both areas showed the same proportion of income.

**Farm size**

The regression analysis for two different ecological zones showed that that relationship of net income from tree components with cultivated land is significant in Jalalabad (P-value 0.00, R sq = 48.2%) as shown in Figure 1. The regression analysis in Bagrot showed that the model is not good (R sq =14.2%), for determining relationship between tree income and the land size. The tree income showed 14% of the variation due to land size (Figure 2). The remaining 86% is variation caused by other factors as shown in Figure 2.

**Impact on natural forest**

The firewood and timber consumption from natural forest was negligible in Jalalabad as compared to Bagrot. The result revealed that in Jalalabad, the average household annual consumption of the wood was 40 kg and the timber was 0.037 $m^3$ from the natural forest. In Bagrot, annual consumption of the firewood was 2975 kg and the annual timber consumption average per house-hold was 1.49 $m^3$ (Table 5).

The estimated quantity of firewood obtained from natural forest in Bagrot was 2875 kg, while in Jalalabad it was only 40 kg per household. In contrast, the estimated quantity of firewood obtained from agroforestry was 4566 kg in Jalalabad and only 633 kg per household in Bagrot (Figure3).
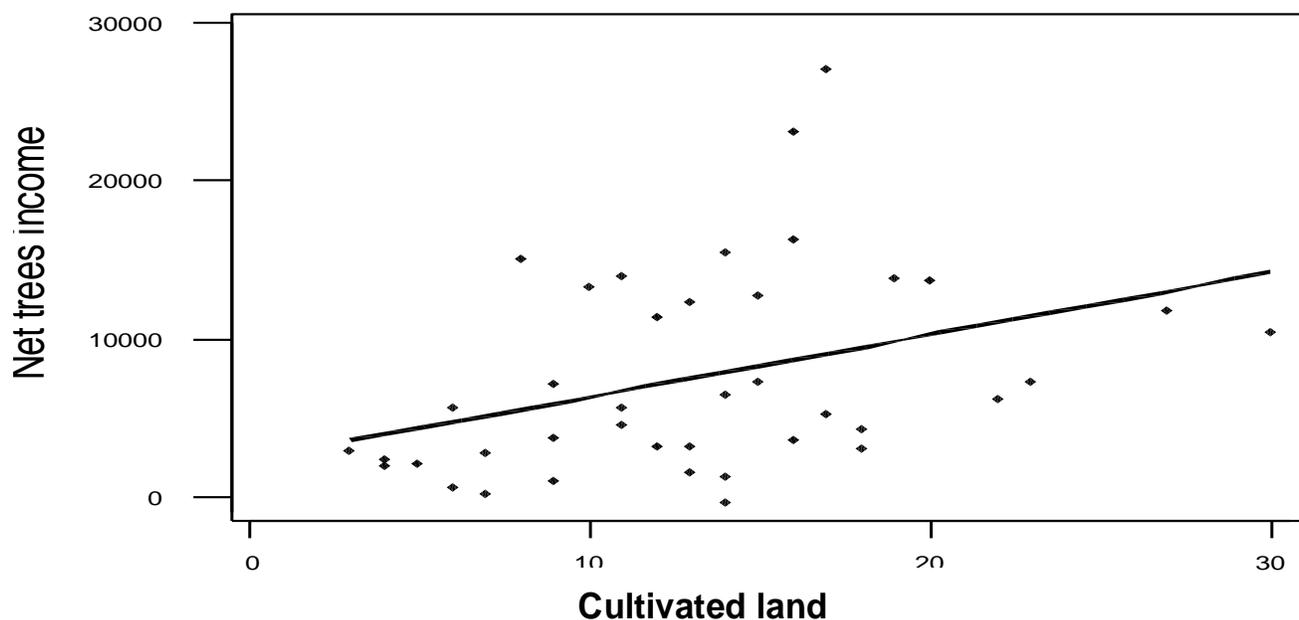
**Figure 2.** Regression analysis of cultivated land and net trees income in Bagrot. Net tree income = 2365.39 + 392.887 C.Land; S = 6001.66; R-Sq = 14.2% R-Sq (adj) = 11.9%.

**Table 5.** The average household consumption of firewood and timber from natural forest in the study area.

| Name of site | Average firewood (kg) | Average timber (m3) |
|---|---|---|
| Bagrot | 2875 | 1.49 |
| Jalalabad | 40 | 0.037 |

## DISCUSSION

The analysis showed that there is significant difference (p = 0.0007) in agroforestry income of the two areas. The income from trees in the agroforestry of double cropping area is three times greater than the single cropping area. There is no significant difference between the two areas in the income from annual crops despite having two sequential annual crops in one year in double cropping zone. The study revealed that the production of wheat per hectare is higher in single cropping zone than double cropping area, because the single crop has more time to properly mature. Similar results were mentioned by Saunders (1983). The analysis of results confirms that the increased income is because of the income from potato production in single cropping zone, as there is significant difference in income from the potatoes in both zones. Single cropping zone is preferred for potato cultivation due to high quality and quantity. *Myzus aphis*, which is the vector of the virus disease, is rare due to low temperature and dry climate at high altitude especially from 2,450 to 3,050 m (Saunders, 1983). Therefore, farmers grow potatoes as cash crop, whereas double cropping area is not appropriate for potato cultivation on commercial scale. The potatoes give good short-term benefit but in the long run deteriorate the soil fertility.

The analysis of inputs shows that expenditure on the seed is more in Bagrot as compared to Jalalabad. This is because more than 70% of farmers purchased potato seed from other internal and external sources. Farmers have experience that the seed from other sources give more productivity than their own seed. For cereal crops, people used there own seeds. The application of chemical fertilizer was higher in Jalalabad as compared to Bagrot. Due to double cropping system in Jalalabad, farmers use chemical fertilizer in the corn. Farmers cannot use the tractor for ploughing in Bagrot due to topographical constraints, so traditional methods of using the oxes in farming are employed.

The income from fruit in agroforestry is US$81.47 per household in Jalalabad and US$ 100.92per household in Bagrot which is significantly different (P = 0.0001). The difference in income is due to the quantity of products. The difference of firewood income from agroforestry in both areas is highly significant. It contributes to 14% of total income, which is equivalent to US$115.85 and in Bagrot it is only 3% of the total income, which is equivalent to US$13.81. The average household income
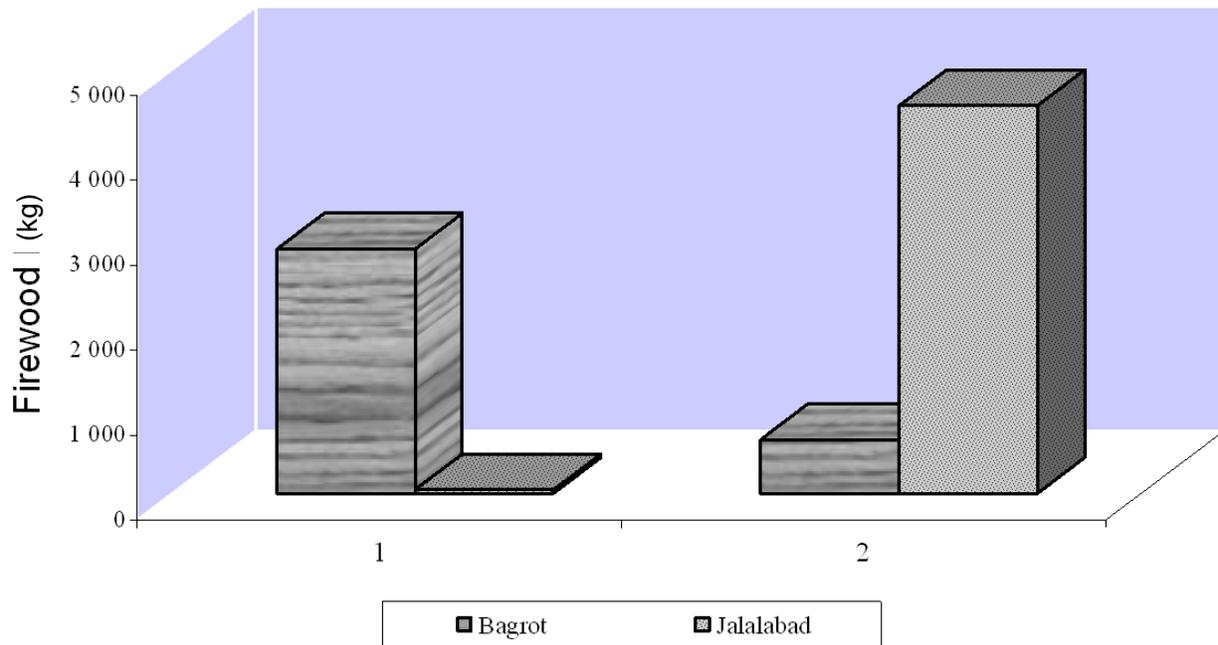
**Figure 3.** The estimated quantity of firewood obtained per household from natural forest and agroforestry.

from the timber is only US$29.8 per year in Jalalabad, while this amount is US$2.8 per year (P = 0.002) in Bagrot.

## Farm size

The results showed that farm size has linear relationship with the agroforestry income. The agroforestry income increases with the increase in farm size. The increase in farm income in large size land holdings is due to the abundance of trees in the farm. It is evident that more trees will be available on more land but it is interesting to note that with increase of farm size, the density of the tree decreases. The farmers who have less land grow a higher number of trees per hectare when compared to the farmers who have relatively large land holding. The regression analysis showed that the income from trees increases slowly in Bagrot as compared to Jalalabad, with the increase of farm size.  It shows that there is smaller number of trees per hectare in Bagrot when compared to Jalalabad. This is caused by three factors. First, the farmers give more emphasis to the cereals due to its food value for their subsistence. This is due to the fact that they keep less density of trees on the farmlands. Secondly, the people of Bagrot have access to the natural forest for firewood and timber. As they are entirely dependant on the natural forest therefore, they are not much interested in planting the trees on their farmland. Third factor is the free grazing pattern. Traditionally, farmers leave the farmlands open after harvesting the annual crops during the fall. The livestock and the cattle

trample and destroy the tree seedlings and saplings. Therefore, only a minimum number of plants survive after planting (Mian, 1985).

## The relationship between agroforestry and natural forest

It is evident from the results that the quantity of firewood and timber consumption from natural forest is higher in Bagrot as compared to Jalalabad, while quantity of firewood and timber from agroforestry is higher in Jalalabad than Bagrot. Bagrot is closer to natural forest and the local population has an easy access to firewood and timber from the natural forest. Contrarily, due to less accessibility to natural forest, the farmers in Jalalabad rely on agroforestry. Being a double cropping area, the growth of trees is faster than single cropping area that gives higher and faster return as compared to the single cropping area. Due to the close proximity to the natural forest the local population of Bagrot relies on forest for firewood and timber. They have limited practi-ces of agroforestry on their farmland. Due to the limited agroforesry practices, there is increasing pressure on the natural forest. It is  argued that the planting of trees on farmland reduces their agricultural productivity and their land holding is too small for afforestation on separate pieces of land. Another reason is due to shorter growing period, the trees have less growth increment as compared to the double cropping area.

The availability of fodder, firewood and timber from  the agroforestry would reduce the threats of  degradation of
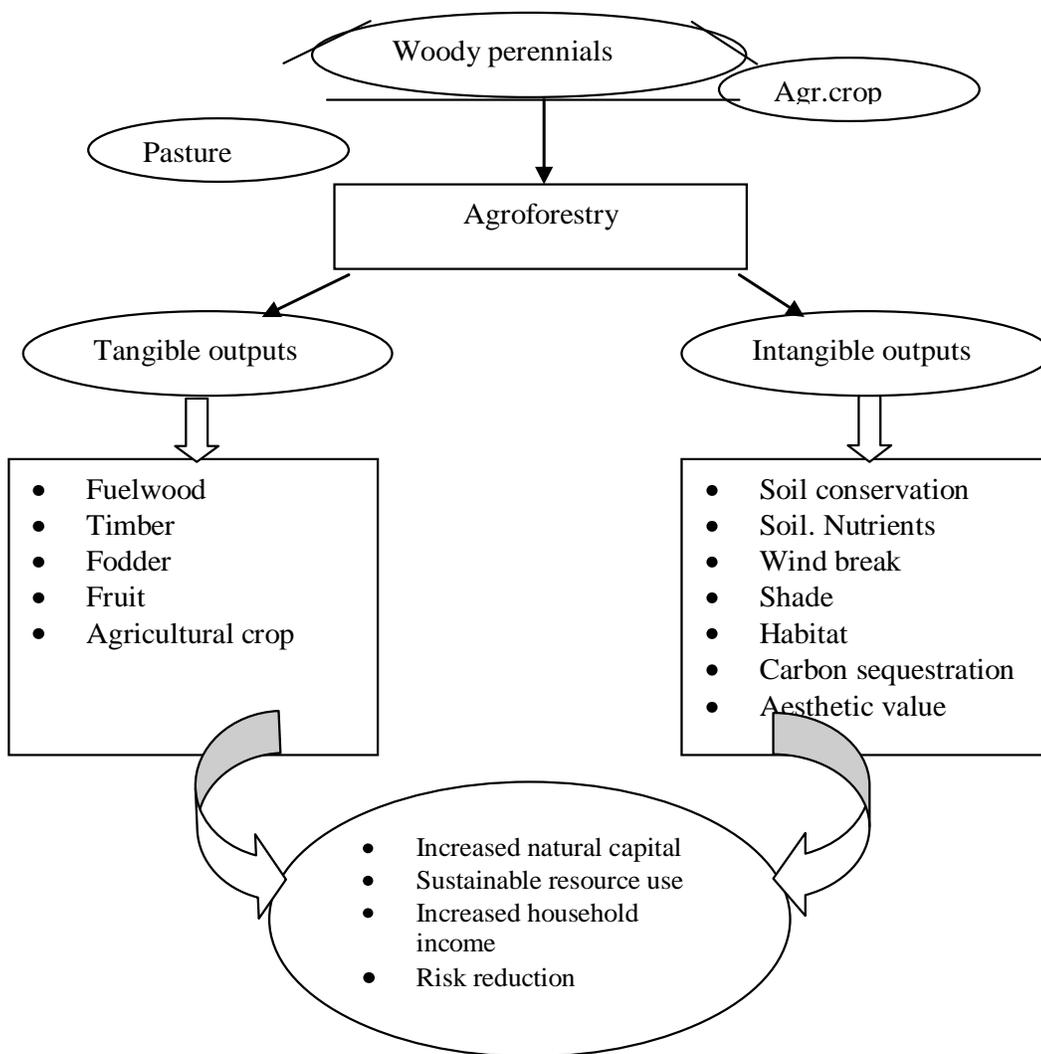
**Figure 4.** The contribution of agroforestry in the livelihood of the farmers.

natural forest and also improve the livelihood of the people and enhance the global benefits through carbon sequestration (Maikhuri et al., 2000). The agroforestry has impact on natural forest conservation in two ways: First the agroforestry increases the farm income over the time, which improves the household economic condition of the farmer as shown in Figure 3. The improved economic conditions increase the choices of alternatives for firewood, for example, use of gas, electricity and oil for cooking and heating (Nasir and Athar, 1998). The other way is the availability of firewood and timber on farm. Both ways reduce the degradation of the forest and impart a positive impact on natural forest conservation.

**Agroforestry framework**

The agroforestry contribute to the livelihood of the farmer through tangible and non-tangible output by enhancing

the natural physical and financial capitals and make the resources sustainable and stable by balancing the nutri-ents and conserving the soil (Figure 4). The farmers take into account only the tangible benefits of the agroforestry; they have either no idea or do not consider the global impact of the non-tangible benefits such as carbon sequestra-tion, soil conservation and habitat. Therefore, the farmers' decision is based on only tangible benefits.

**Conclusions**

This study was designed to analyse the agroforestry income such as tree component and annual crops in two selected sites. It is concluded that in agroforestry, the combination of trees with the annual crops increases the overall farm income of per unit land area of farmland and reduces the risks and broadens the sphere of alterna-tives. A positive relationship was found between the

income and farm size. With the increase of land, there is increase in agroforestry income. The increase in agroforestry income in large size land holdings is due to the abundance of trees in the farm.

By analysing the agroforestry income in two different agroecological zones, it was concluded that there was a difference in the income. The main factor which affects the income of the farmland is growing season, which is a function of altitude. The longer growing season in the double cropping area enhances the agroforestry income. We observed that the change in agroecological zone also changes the cropping pattern and the choice of the species.

The agroforestry directly reduces the rate of deforestation of natural forest through increase of farm income and makes available firewood and timber on the farmland. The easy access to the forest declines the interest of the people towards the agroforestry. Finally, it is concluded that agroforestry is prerequisite for the conservation of natural forest.

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