Chapter VI Discussion and Possible Solutions

6.1 Land use

Launching land allocation policy in 1993 has remarked an important change in land use strategy in Vietnam. Like other provinces in the whole country, in Son La, most of land resource was allocated to individual farmer household with the long-term land use right. This has motivated the agricultural production changed more effectiveness in terms of land use and cropping pattern because the level of investment in agricultural production has increased sharply as compare with previous years at household level (Thu *et al*., 2001). In agriculture, land was distributed to different crops, such as rice, cassava, maize, sugarcane etc and fruit trees, in which maize, cassava and sugarcane were seem as main cash crops in the upland area (Table 3 and Table 5) which annually have brought a remarkable benefit for farmers. Land use for wet land rice occupied small area with purpose is to be self-sufficient, average size is about 0.08-0.13 ha/ family, rice was cultivated at the fields along streams or terrace fields where could access with water resources. In the upland, the highest land proportion belonged to maize production; the average land area for maize production varied from 0.2 to 0.5 ha/household, which mostly concentrated in the midland area.

Other upland crops such as cassava, sugarcane and soybean are cultivated in both the midland and steepland area. Land use for these crops occupied about 30-40 percent of total land area of each household in upland area. However, result of land allocation that made agricultural land of farmer household to be separated into many plots in different location. Data in Table 6 showed that each farmer household owns from 7-10 land plots in different land types, this is a major difficult in practice and crop management.

Pressure of population and food demand that made agricultural land expanding up to steep land area to meet food demand, the main crops in this area consists of upland rice, maize and cassava. This dynamic has made the agro- ecological system in this area changes toward instability. So the negative impacts to agricultural production, crop yield and environment, such as drought, soil erosion, and flood and soil degradation are unavoidable. These problems are similar with the results were found out by Siem *et al.,* (1999) and Tuan *et al* (2001) on the slopping land area in the northern of Vietnam.

6.2 Cropping system

Complexity of topography and climate conditions has set up the specific cropping systems for this area. The result of field survey noted that most of annual agricultural activities in this area concentrated in rainy season from April to August. The cropping system was not very complexity with three dominant cropping systems, which consisted of slash and burn practice, upland field crops and low land rice.

The slash and burn practice: This type is existing with small area in the steepland and remote areas, it belonged to the minority groups, such as Dao, Hmong, Man, San, Tay, Nung, Muong peoples etc and traditional cultivation techniques were applied in production. The main crops for this system comprise of upland rice, cassava and sticky maize with main purposes of this system were self-sufficient to serve for daily food demand for peoples and home husbandry consumption.

Upland field crops: This cropping system was considered as the backbone of agriculture in the rainfed area of Son La province. Crops consisted of maize, cassava, soybean and sugarcane, which occupied from 60 to 70 percent of upland area. Of which maize was seem as a main crop and dominated in this area. Monoculture was a major field practice in the study sites, it accounts for 40 to 70 percent of framer household applied this practice. Mixed crop and intercropping were not common in this area, which occupied only from 10 to 20 percent of total farmer households applied these methods in production. The agricultural products, such as maize, cassava and sugarcane from this system mainly severed for market demand.

The wetland rice system occupied with small area with purpose to be self-sufficient at household level, which was cultivated in the terrace fields and the lower parts where could get and controlled water resources from streams and from the rest of forest area in the top of the hills or the rock mountains. Normally, in the rainfed area, only summer rice was transplanted in rainy season (April-August) because of lack of water resources and poor irrigated system. In some other areas, wetland rice was transplanted with two crops per year, which consist of spring rice and summer rice that thank to available water resources and having the irrigated system.

6.3 Maize production

Maize was cultivated in Son La province as a main food crop for people in long-term history. Before 1990s maize was planted to server for human food demand and it played an important role in food security strategy in Vietnam at that times (Uy., 1998). To day, the role of maize has become more importance; maize was not only produced for home consumption but also provided for feed industry market demand and it was considered as a main source income of maize growers in this area. The market demand made the maize production in this area rapidly shifted toward the semi-commercial production type. The result of field survey summarized in Table 11 showed that in Co Noi was 80.0 percent, follow by Ang was 66.6 percent, Ban Hoa was 46.7 percent and Chieng Ban was 36.7 percent of farmer households among villages produced maize following the semi-commercial production type.

6.3.1 Land use for maize

Maize covered all upland area from narrow valleys to steepland areas (Figure 9). According to farmer evaluation, the most suitable areas for maize production were valleys and land areas having slope less than 10^0. The characteristics of this land type were described in Table 9. The soil in valleys was result of accumulation of sediments from the higher parts of hills so that the organic matter content in the soil was quite high and the other soil characteristics, such as nutrients, moisture, and bulk density and soil texture were better than as compare with other areas. Moreover, this area was less suffered from natural disasters that could support for crop growth and produce better yield at the field. Consequently, the average maize yield from this area usually gets higher than other area. However, this land type only occupied with small size from 6.0 to 30.0 percent of the total maize area within villages so that contribution of maize in this area was not so much to the total maize production in the whole area.

The midland area is body part of maize area, maize was grown in the plots having slope from 10-20^0 with different soil characteristics. The adulating topography and long-term cultivation without soil conservation methods and the environmental stress, such as drought, erosion always affect the soil quality declined rapidly, especially in the land plots with higher slope. Accompanying with soil erosion, the changes in soil characteristics, such as declining of pH, low soil fertility and soil degradation were factors leaded to the soil fertility was not homogenously within plots in the midland area. Consequently, the maize yield has trend to be lower than in the flatland area and instable among farmer households in this area.

The steepland area with slope higher than 20^0 is considered as the less suitable area for maize production because this area has been strongly affected by eroding. Accounting for this land type, it occupied from 2.0 to 20 percent of total maize area within surveyed villages (Table 10). Under eroded circumstance, the topsoil layer has been changed, and nutrients, such as nitrogen, phosphorus, calcium and magnesium etc were taken out of maize system that leaded to acid soil and soil degradation were susceptible after several cultivated years that is main reason made the annual maize yield obtained was quiet low and fluctuation year to year.

6.3.2 Fertilizers use for maize

In order to a crop to express its full potential in production, it is essential that nutrients requirement should be fully supplied. The essential nutrients for maize growth consists of major elements, such as nitrogen, phosphorous, potassium, calcium, magnesium and minor elements, such as zinc, copper, iron, manganese etc need to applied appropriately. The purpose of fertilizer application is to make any shortfall duration and provide nutrient availability in the soil and prevent nutrient shortage from limiting growth (Corrazzina *et al*., 1991)

In Vietnam, the recommendations of fertilizers application for maize are different from locations and varieties; amount of fertilizer application depends on the status of soil fertility and the particular varieties use in production. According to Long (1998) amount of fertilizers should use in the alluvial soils in the southern of Vietnam, for OPVs nitrogen from 60 to 120 kg per hectare, phosphorous from 40 to 80 kg per hectare, potassium from 30 to 60 kg per hectare. For hybrid maize varieties, fertilizers applied should be higher than nitrogen from 150 to 200 kg per hectare, phosphorous from 60 to 90 kg per hectare and potassium from 30 to 60 kg per hectare. According to Phong (2002), the amount fertilizers should use for DK_{999} in the north region of Vietnam nitrogen 140 to 200 kg per hectare, phosphorous from 65.0 to 85.0 kg per hectare and potassium from 60 to 100 kg per hectare. However, the amount of fertilizers use could be controlled depending on the status of soil fertile and crop in the growing season.

On the rainfed area, in order to obtain the yield from more than 4.0 tons per hectare, the amount of fertilizers should be applied for hybrid maize are: farmyard manure from 8 to 10 tons per hectare, nitrogen from 150 to 200 kg per hectare, phosphorous from 75.0 to 90.0 kg per hectare, potassium from 80 to 100 kg per hectare. For the OPVs nitrogen from 120 to 150 kg per hectare: phosphorous from 60 to 90 kg per hectare, potassium from 20 to 60 kg per hectare combine with farmyard manure from 5 to 7 tons per hectare. Moreover, in order to increase the efficiency of fertilizer, maize growers should apply lime; amount of lime application depends on the pH soil at the field (Truong *et al*., 2000, Can., 1976).

Making comparison of fertilize used in farmer practice (Table 12, Table 13 and Table 14) with the fertilizer recommendation rate, which indicated that average amount of fertilizers used in farmer practices were lower than recommendations rate, even in the midland and flatland areas are the central areas for maize production. Moreover (Table 15) showed that 100 percent of farmer in the steepland and approximately 60 percent of farmer in the midland and flatland applied fertilizer under the recommendation rate.

Field survey also indicated that all maize growers haven't used farmyard manure in maize production for long times, which leaded to the organic mater content in the soil was declined rapidly after several cultivated years. The low organic mater content in the soil is major cause of the low soil productivity and made the maize yield was declined and fluctuated year to year in the steepland and a part of midland area.

6.3.3 Maize yield and yield gap

The average maize yield obtained among land types of the upland area was presented in Table 16. In the flatland area, the maize yield obtained from 3.0 to 6.3 tons per hectare that thanked to the good soil quality and less of environmental stress. The midland area, the central area for maize production, the maize yield obtained from 2.5 to 4.2 tons per hectare, was lower than as compare with the flatland. The lowest maize yield obtained in the steepland area, where having slope higher than 20^0 is seem as the less suitable area for maize production, it varied from 1.14 to 2.58 tons per hectare within surveyed villages.

The yield gap analysis (Figure 10) revealed that the low yield in the steepland and midland was result of yielding constraints has involved at the field in growing season including drought, soil erosion, soil characteristics and technical constraints, such as variation of input use, varieties use and technical employment. In addition, the different impact level of yielding constraints was major cause leaded to the variation of maize yield among land types, the low yield in the steepland (2.3 tons per hectare) and midland (3.7 tons per hectare) in average as compare with the yield obtained in the flatland could explained by differing in eroded level, input used and field practices. The high yield in the flatland area (5.0 tons per hectare) thanked to the good soil, high input used, hybrid varieties and the less erosion effect.

The Figure 11 showed that different variety used is considered as a factor made the yield gap in maize production of Son La province. The lack of credit sources for buying the hybrid varieties that leaded to the existing local varieties and OPVs in production, at the farmers used local varieties and OPVs, the yield obtain were lower than as compare with the farms, which used hybrid varieties. The largest yield gap occurred between hybrid varieties and local varieties 3.02 tons per hectare, follow by the gap between hybrid varieties and OPVs was 1.84 tons per hectare and the lowest yield gap was 1.18 tons per hectare between OPVs and local varieties.

The yield gap not only occurred in different land types but also occurred at the same of land type (Figure 12, Figure 13 and Figure 14). The main reasons for this problem were technical constraints, which consisted of difference in varieties used, fertilizer application rate, timing of fertilization application, weeding control, and pest and disease control etc that made to the yield gap among farmer households.

6.4 Constraints and its relative important

It is very difficult let maize to fulfill its potential yield in production because the yielding constraints both of biotic and abiotic factors always affect it in growing season and mass of yield loss due to constraints depends on the degree of effect of constraints and its interaction types (Mduruma *et al*., 1996). The result of PRA workshop identified and described the effect of constraints to maize productivity in the rainfed area, such as drought, erosion, old varieties, low soil fertility, low input use, inappropriate fertilizer use, weed and pest problems and farmer lack of technology (Figure 15), which made the low yield and instable. This results were similar with the reports of Sajjiapongse *et al*., (1998), Phien *et al*., (1996) on constraints to the upland crops on the rainfed area in the north of Vietnam.

On the aspect of farmer evaluation of the effect of yielding constraints to maize productivity, the prioritization defined the relative important of constraint through weight values of each in the particular land type (Table 18, Table 19 and Table 20). The result showed that In all of land types, the first group of yielding constraint was assigned with highest weight value for drought and soil erosion, the second group of yielding constraints consists of old varieties, low soil fertility and shortage and imbalance in fertilize application. The last group of yielding constraints includes weed, pest and diseases, and farmers' lack of advance technologies. These problems often occur in maize production and yield loss is simultaneously in tropical maize area (Edmeandes *et al*., 1996, Toan *et al*., 1999).

Considering for constraints to maize productivity in the whole areas, in general, the yielding constraints affected maize productivity, which can be ordered base on the degree of effective level. It follows by drought, soil erosion, old varieties, low soil fertility, and shortage and imbalance in fertilizer application, pest and diseases, weed competition and farmer lack of technologies. The gap of maize yield because of these yielding constraints, depends on the particular condition and severity effective level at the field during growing season (Dalmacio., 1998)

6.5 Quantitative assessment on yielding constraint factors

Quantitative assessment on the effect of yielding constraints was estimated by Cobb-Douglas production function. The coefficients of inputs were positive values (Table 22), it reminded that maize yield could increase if maize growers pay more attention to nutrient application rate, in which nitrogen and potassium are seem as most important to increase the maize yield. The dummy variables of model received negative values from model. It confirmed that if these constraints occur in the farmer farm, the yield loss due to them in those farms is unavoidable. The limitation of quantitative assessment is drought variable, which was not able to estimate because of lack of time series data so that yield reduction under drought stress was estimated by farmer evaluation and farmer responding in the field survey.

6.5.1 Drought

Heavy yield reductions caused by drought are common in maize production fields throughout the world (Beck *et al*., 1996). Drought can be defined as any duration without rainfall, which is long enough to reduce to plants growth (Njoroge., 1996). Drought related to shortage of water is considered as a major constraint in maize production in the tropical area. The maize yields affects dramatically, if drought appears at the flowering stage and during grain filling. Evaluation of the effect of drought to the maize production Logrono *et al*. (1996) noted that drought often affects in regional scale and not only damages the maize yields but also reduces cultivated areas due to shortage of water.

In this study, although regression model was not able to estimate the average of yield loss due to drought because of lack of time series data. However, according to farmer evaluation, if drought occurred within sowing time, the geminate rate would reduced in the plant density and yield per unit area also declined, for this problem it could be overcome by replanting. If drought appears at the flowering state, or during grain filling, grain couldn't fill up the cob. Assessment on the yield loss due to drought, farmer estimated that the average yield loss varied from 25 to 40 percent as compare with potential yield, which depends on the length of drought duration. The percentage of yield loss in above is quite higher than the result of Logrono *et al*. (1996) estimated on maize yield loss due to drought stress in Vietnam varied from 15 to 20 percent as compare with the unaffected maize fields in the year having favorable weather condition.

6.5.2 Soil erosion

A worldwide concern about the soil erosion problem today, soil erosion has adversely impacted to agricultural production, water quality and many other issues. The consequences of soil erosion are low pH, poor soil fertility, soil degradation, crop yield reduction, and huger and environmental pollution etc (Siem *et al*., 1999).

The result of field survey showed that all of farmers agreed that soil erosion has directly affected maize production through changing in the topsoil layer and removing of nutrients from the field by runoff, leaching and soil loss. The highest risk of maize field would happen if soil erosion occurred at the early growth stages of maize, when maize has two or four leaves. Because at the early stage, the root system of maize easily injures when the topsoil layer to be removed that made the rehabilitation of maize in the next stages is very difficult. Even, maize crop could be removed from the field accompanying with movement of the topsoil layer. Consequently, it limited the growth rate and reduced the potential yield. The reports of and Langdale *et al*. (1985) noted that the erosion strongly affected the maize yield, the mass of maize yield reduction depends on the severity level of soil erosion, it varied from 1.25 to 4.83 tons per hectare, respectively under the slightly and moderately soil erosion level.

In this study, the yield loss due to soil erosion was estimated base on the coefficient of dummy variable soil erosion D_3 = -0.286. It showed that if erosion occurs at a farm in growing season, the average yield loss was 25.0 percent, it equals to 1471.0 kg per hectare as compare with the maize yield at the unaffected farms (Table 23). Regarding to the long-term effect of soil erosion on the crop productivity, Siem *et al*. (1999) also noted that the crop yield not only reduces in the first year but also continuously reduce in the next years because of soil degradation, in order to rehabilitate soil productivity, it could take at least 25 years later.

6.5.3 Old varieties

Worldwide accepted that the new variety played an important role in improving of crop yield. Conway. (1997) showed that the breeding program is a breakthrough in agricultural development in the global scale. In maize production, the replacing the old varieties (local varieties and OPVs) by hybrid maize varieties has significantly increased the total of maize production. The average yield increased from 20 to 50 percent thanks to hybrid varieties and advance techniques were applied (Uy., 1998).

In Son la, hybrid varieties, such as LVN 10 and DK_{999} were more attractive with maize growers because yield of these varieties provided higher than OPVs and local varieties. Although hybrid varieties have widely applied in production about 87 percent of total maize area of Son La province (Toan *et al*., 2002), a number of maize growers have still use OPVs and local varieties in production because of lack of credit sources that made the total of maize production in this area lower than as its potential. Evaluation of this constraint to yield gap, the estimated result of variety dummy variable, old varieties in the model D_1= -0.279 (Table 22), which affirmed that average yield gap due to the constraint of old varieties was 23.6 percent (Table 23) as compare with the farms used hybrid varieties in production.

6.5.4 Low soil fertility

All of maize growers in villages concern about the decline of soil fertility coupled with low nitrogen content in the soil because it has directly affected maize production. The soil fertility is declined due to many reasons, in which, erosion and long-term cultivation without inorganic fertilizers application are major causes of this. Frye *et al*., (1985) estimated that the mass of nutrients out of the field due to soil erosion per year could be 807.7 kg of organic matter, 55.16 kg N, 78.80 kg P_2O_5 and 10.74 kg K_2O. Nutrients remove from the soil that leaded to the deficiency of nutrients, especially, nitrogen deficiency that strongly limits growth rate of maize. Under this circumstance, maize provides good yield like its potential is seldom so that yield reduction is unavoidable under the low nitrogen and low soil fertility conditions.

The pervious researches reported that accompanying the low soil fertility or soil degradation is the low nitrogen status in the soil that is considered as a limitation of agriculture in slopping land so that crops and its yield is not able to fulfill like expectation (Vien., 1996). Under the low nitrogen soil fertility circumstances, the average maize yield declined is remarkably, it varied from 20.0 to 30.0 percent of its potential yield (Thanh., 1996, Logrono *et al*., 1996).

Evaluation on the effect of low soil fertility on yield loss in this study, the model estimates the effect of low soil fertility by dummy variable D2= -0.2288 (Table 22). It means that if maize is grown at farms which have low soil fertility, the average yield reduction under low soil fertility farms compare with good soil farms was about 20.4 percent of maize yield (Table 23). As a field surveyed result in son La province indicated that the low soil fertile is popularity in the steepland and midland area so the effect of low soil fertility to maize productivity was well as total of yield loss due to this problem is quite high in the whole area.

6.5.5 Shortage and imbalance in fertilizer use

In order to increase the fertilizer use efficiency, it is the necessary to apply fertilizer for crop with optimum levels in particular soil condition. Moreover, the fertilizer kinds, fertilizer rate, ratio and timing application should be considered. Balanced fertilization strategy is considered the most importance in term of fertilizer use in agricultural production because imbalanced fertilization not only decreases efficiency of fertilizer use on crop but also affects the growth rate of crop and yield and ground water due to runoff and leaching (Bo: Online).

Discussion on the fertilizer application for maize, the data in Table 12, Table 13 and Table 14 showed that the amount of nutrient application in farmer practices is quite lower than as compare with the recommendation rates (Corazzina *et al*., 1991, Can., 1976). In addition, model estimate for the coefficient values of nitrogen, phosphorous and potassium variables are positive (Table 22), it means that these elements (N, P, K) were underused in farmer practice. In other word, the shortage of fertilizers use for maize is reality in this area. Therefore, in order to increase maize yield farmer should invest more fertilizers in production, especially, nitrogen and potassium because of the coefficient of nitrogen and potassium in model are positive at significant in term of statistic. The coefficient of phosphorous in model is non-significant in term of statistic, it implies that the maize yield will increase unremarkably when farmer increase amount phosphorous application.

The low efficiency of phosphorous in slopping land is commonly phenomena because the soil erosion made the Ca^{++} and Mg^{++} cations were leached that leads to pH in the soil to be declined sharply and toxicity elements, such as Fe^{2+}, Al^{3+} increased. Under acid soil circumstance, most of phosphorous apply in the soil to be fixed by Fe^{++}, Al^{+++} cations (Greenland *et al*., 1981). That leading to the available phosphorous forms in the soil is often quite low, the and root system of maize can not uptake phosphorous from fixed components so that the efficiency of phosphorous was often low-significant contribution to crop yield on slopping land unless the pH is improved by lime application (Phien *et al*., 2000)

Moreover, the no application of FYM for maize is considered a major cause of organic matter content reduction in the soil. On other hand, the other soil characteristics, such as soil texture, soil structure, soil water retention, soil porosity etc were declined forward the worst trends that also affect the growth rate of maize and the efficiency of chemical fertilizes due to the bad soil status.

On the aspect of yield gap due to the shortage of fertilizer application was calculated via the coefficients of input use (Table 22) and amount of average fertilizers were applied in farmer practice. Because amount of fertilizer application were different in individual farmer household so that we can calculate the yield gap of each household compare with the average yield was calculated (Table 23). The largest yield gap defined between the lowest inputs and highest inputs use level and without any constraints occurred at the farm during growing season, which equaled to 16.2 percent, in which contribution of nitrogen was 11.2 percent and potassium was 4.8 percent to yield increase. Thus, the yield gap due to non-optimum fertilizer use ranged from 0 to 16.2 percent of maize yield as compare with farmer households who used fertilizers at the optimum level.

6.5.6 Weed competition

Weed competition is commonly in the crop field, interplant competitions for capture of the essential resources, such as light, water and nutrients for plant growth. If weeds capture such resources, the growth rate of crop will be reduced, as result the crop yield will be loss. The contribution of weed competition to average yield loss was 10 percent of agricultural production in worldwide. Without weed control, yield loss could be reduced from 10 to 100 percent, depending on the competitive ability of the crop (Kropff *et al*., 1993).

Field survey and transect walk showed that in the midland and steep land area, farmers had faced with many kinds of weed, such as *Imperata cylindrical, Eleusine indica* L, *Paspalum distichum* L, *etc*. Weeds can dominate the crop and make yield loss if weeding control not pays attention to during growing season. Most of farmer noted that in order to minimize the effect of weed on the growth rate of maize, farmers need to control weed from 2 time to 3 times before maize leaves closing. However, a number of farmer households only carried out one time of weeding control because of shortage of labor so that at these farms so that weed has affected the growth rate and made maize yield reduction. Regarding in weed problem and its effect on maize yield, the coefficient of dummy variable for weed competition was estimated D_3 = -0.058 (Table 22) and the average percentage of yield loss due to weed problem was 5.7 percent as compare with the unaffected farms (Table 23). Comparison with result of previous studies (Kropff *et al*., 1993), the average yield loss was lower than, that could be explained by weeding control at that farms was done incompletely during growing season.

6.5.7 Damage of insect and diseases

The pest and disease are biotic constraints; it often appears within growing season and the damage to maize yield. The field survey found that annually maize was attacked by rootworm, wireworm, stem borers, spider mites, and grasshopper. The diseases affect maize, such as *brow sport*, *downy mildews* etc. These insects and diseases can occur at any stage of maize in production. The mass of yield reduction varies from 10 to 50 percent of potential yield (Pingali *et al*., online), depending on the damage level and particular insect and disease attacking.

Although all most of maize growers used the chemical pesticides to reduce the damage of insects and diseases that significantly contributed to maize yield reduction, the yield reduction still occurred remarkably at these farmer farms who reluctant with pest and diseases control in the steepland and midland. Evaluation of the yield loss due to pest and diseases problem, the coefficient of dummy variable of pest and diseases damage D_4=-0.084 (Table 22) and the average percentage of yield loss due to this was 8.1 percent as compare with the unaffected farms (Table 23).

6.5.8 Farmer lack of technology

In recent years, extension network in Vietnam has grained the great successful in agriculture promotion in the whole country. However, the lack of technologies is still popularity in minority groups in the high land areas where having poor infrastructures and people with high illiterate rate that make communication very difficult (Shanks: Online). Evaluation of the technology accessibility, most of maize growers in the flatland and midland area have agreed that they could access with extension network to get new technical information and apply in maize production. However, a number of maize growers in these areas, especially, people in the highland areas, could not contact with extension staffs so that they did not directly receive any technical information from them. Instead of that, they adopted by the others.

On aspect of the yield gap due to farmers' lack of technology, the dummy variable for lack of technology was negative value D_6= -0.023 (Table 22) and non-significant in terms of statistic. It means that the yield reduction with 2.3 percent for this problem is non-significantly in the real word (Table 23) as compare with maize yield at the farmer households who could assess with formal extension network. The indifference in terms of the maize yield between two maize producer groups could be explained that although maize growers did not directly get any information from extension services, they could indirectly get technical information through other persons who had contacted with extension services. Thus, beside the formal extension channel, the role of the farmer-to-farmer network has importantly contributed to maize production and motivated agricultural production in this area. The other reasons for the indifference in the maize yield at two groups, which could explain by the different in the farm resources, farmer knowledge etc that has helped farmers who could not access with extension network but the yield return was equaled with the others.

6.6 Possible solutions for maize production

Looking for future maize development, both scientists and maize growers, no body agreed that the constraints would not continue in tomorrow. Evaluation of the constraints to maize productivity, which showed that some constraints not only affect maize in growing season but also long-term effect to maize production because the degradation of natural resource. Therefore, making the solutions to minimize the effect of constraints to maize production and improvement maize productivity in the future in this area is very necessary.

In PRA workshop, farmer defined the relative important of constraint to maize productivity. The relative important of constraint was considered as the basic to make possible solutions. The result of farmer discussion in PRA workshop defined the possible solutions for improving the maize productivity as follow were:

Solution 1: Establishing the soil conservation model by planting the green hedgerows in the maize field like establishing the agro-forestry model, which is considered as an integrated solution to control soil erosion, rehabilitate soil fertility and improve water regime.

Suggestion for using *Tephrosia candida* to make green hedgerow in soil conservation model to control erosion was interested by farmers. Because this method is more suitable with their ability and local conditions, the source of *Tephrosia candida* seed is available in villages so that farmers easily collect seed by themselves. Moreover, the design of green hedgerow contour line along hillside can implement easily by farmers and require less labor forces. Therefore, if we evaluate the technological and economic feasibility for establishing the soil conservation model by making green hedgerow (*Tephrosia candida*), it could fully accept with the local conditions.

The promise of green hedgerow would contribute to reducing of soil loss during the rainy season as the green hedgerow is normally planted along the hillside, it can break the surface runoff under heavy rain so that amount of soil loss will reduce remarkably. According to Tam *et al*. (1996), Toan *et al*. (1998) reported that *Tephrosia candida* was planted in the field crop on the slopping land, the amount of soil loss had reduced from 33 to 45 percent as compare with farmer practices.

Low soil fertility has found widespread in slopping land, the main cause of this problem is declining of the organic matter content in the soil due to soil erosion and long-term cultivation without organic fertilizers application. Loc *et al*. (1997) found that planting the green hedgerow in the field, which annually returned into the soil from 1.5 to 2.0 tons of green material per ha. Moreover, using stems and leaves of *Tephrosia candida* as green manure, it is not only improve the soil fertility thanks to the nitrogen content in the stem and leaves of *Tephrosia candida is* quite high (Powers *et al*., 2000), but also increase the soil holding water capacity, reduce drought because the organic mater content in the soil has increased (Blamy *et al*., 2000).

Solution 2: Increasing amount of fertilizer use for maize upon on the scientific recommendation, especially, in the steepland and midland is considered as an important work to improve maize yield.

Suggestion for increasing the amount of fertilizer use in maize production is an important work because maize could only produces a good yield when it is fully supplied in nutrient elements in both rate and ratio (Corazzina *et al*., 1991). The analytical result of fertilizer use for corn and quantitative assessment showed that most farmers in this area used fertilizer under scientific recommendation rate, especially, in the steepland and midland area. Therefore, the suggestion for farmers increase amount of chemical fertilizer use is precondition to improve maize yield. The amount of fertilizers use should be followed: for hybrid varieties, nitrogen from 150 to 200 kg per hectare, phosphorous from 75.0 to 90.0 kg per hectare, potassium from 80 to 100 kg per hectare. For the OPVs, nitrogen from 120 to 150 kg per hectare, phosphorous from 60 to 90 kg per hectare and potassium from 20 to 60 kg per hectare (Truong *et al*., 2000).

Aside from that, in order to increase the efficiency of fertilizer, maize growers should apply lime; the amount of lime application depends on the pH soil at the maize field. It would contribute to increase the pH value, reduce amount of phosphorous to be fixed by the iron and aluminum. Moreover, farmers should utilize the available green manure sources and crop residues in villages to apply for maize. By that way, it not only provides the remarkable nutrient source for maize, but also improves the soil productivity after several cultivated years thanks to the soil characteristics were improved (Shirani *et al*., 2002).

However, as the chemical fertilizers price is quite high in the market so that it will be very difficult for the poor farmers. Therefore, in order to meet in time the farmers' requirements in maize production, the credit system support should be available and provided to the poor farmers at the local with the special interest.

Solution 3: It is essential to calling for the support from the extension services to conduct the trials, demonstration models on maize production to select the suitable varieties. It aims to gradually replace the old varieties by hybrid varieties with high potential yield, especially, the varieties can tolerate with drought and low soil fertility conditions.

Farmer suggested that beside the soil erosion control and appropriate fertilizer use, in order to improve maize yield in this area, the replacing old varieties in the midland and flatland area by the hybrid varieties is one of the important work need to be done. Because the ability of hybrid varieties normally produces a higher yield than as compare with the OPVs and local varieties. The varieties were suggested for replacing consisted of LVN10, LVN20, LVN34 and DK999, of which, the LVN10 and DK999 are good varieties, have been using in the villages since 1994. However, in order to widely use LVN20 and LVN 34 in production, the suitability of these varieties with the local conditions need to be tested before. Moreover, credit support also provides to the poor farmers to buy hybrid varieties.