# Effects of land use change on the soil physical and chemical properties and fertility of soil in Sajadrood catchment

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**Abstract:** Prioritizing and expanding the agricultural activities by increasing the agricultural commodities are the strategies to create a balance between the increasing population rate and food production to meet the increasing needs of human beings. The existence of suitable water and soil are the main factors for these activities. In this study the influence of changing the exploitation of pasture system to farming land system on the physical and chemical properties of the soil in one selection in Sajadrood catchment in the north of Iran was investigated. Samples were taken at two depths (0-10 cm and 10-20 cm) in four sites. After experimentation, the gathered data were analyzed using SPSS 21.0 software program. The results showed that the amount of soil bulk density, amount of organic carbon and the percentage of clay were increased in farming lands in comparison with pasture. In pasture with the depth increase, there is a reduction in acidity and percentage of the moisture saturation percentage, but there is an increase in the amount of neutral substances and the percentage of clay, with the depth increase (10-20 cm). Generally, in most sections, the amount of physical and chemical change in farm lands by changing the use is lower than pasture.

**Keywords:** farming land, pasture, physical properties, Sajadrood catchment

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## 1 Introduction

Forest land is rapidly converted into agriculture or pasture land. Land-use conversion may cause important changes in physical and chemical characteristics of soil and can affect soil fertility, increase soil erosion or cause soil compaction (Neill et al., 1997). Soil and water are main elements of agriculture and natural resources and also mentioned as basic economic factors of every country. So, effort to save these sources not only protect the environment but also, ensure economic, cultural, social and political independence that considered as sustainable development. The increasing rate of population and human being need to food leads farmers among different countries to utilize poor and marginal lands such as pastures and woods located in high potential of erosion and low production (Klingebiel and Oneal, 1992). It’s clear that land-use change is the main component of environmental change in every region. A change in the use is the most important factor that influences the protection of natural ecosystems (Layon, 1999). The main pattern of change in land use can be categorized in two main groups: 1. Increase in agricultural farms according to the destruction of the natural ecosystems such as pasture and forests due to population growth and universal increasing rate of need to food, 2. retrieve the ecosystems that are affected by dangerous marginal agricultural lands (Boix-Fayos, 2001). Organic matters are considered as one of the most important factors among soil quality indexes and have a positive effect on soil properties. Soil organic matters (SOM) are the central indicator of soil quality and health, which is strongly affected by agricultural management

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(Farquharson et al., 2003). SOM are complex combination of many soil properties and nutrients cycle. Its amount depends on the kind of land usage, soil type, climate and plant cover (Loveland and Webb, 2003). Geissen et al. (2009) in a study to investigate on the effect of change in land use on soil chemical properties in tropical regions in south-east Mexico declared that the changes in land use in 15 years had no significant effect on soil properties. Chibsa and Ta'a (2009) carried out a study on assessment of SOM contents under four land use systems in major soils of Bale highlands. Major soil parameters affecting SOM storage as affected by land use systems at 0-5, 5-15, 15-30 and 30-60 cm soil depths were evaluated. The result indicated that the distribution and abundance of soil organic carbon were varied independently in all land use systems. There was constant decrease in soil organic carbon storage with increasing soil depth in all land use systems in all locations. The soil was clay in texture and was negatively correlated with soil organic carbon stocks. Martinez-Mena et al. (2008) had done an experiment to evaluate the impact of water erosion and cultivation on the soil carbon dynamic and carbon stock in a semiarid area of south-east Spain. They concluded that change in land use from forest to cultivate enhanced the risk of erosion (total soil loss in olive cropland seven-fold higher than in the forest area) and reduced the soil carbon stock (in the top 5 cm) by about 50%.

Considering lack of study on change in land use in this area, attempt has been made to investigate on the effect of change pasture to farm land on many chemical and physical soil properties in the Sajadrood catchment.

## 2 Materials and methods

The Sajadrood catchment is located in the south of Babol County within 36°9′ and 36°10′ north latitude and 52°30′ and 52°40′ east longitudes, Figure 1. It is nearly 118.8 $km^2$ that 98.4 $km^2$ (83%) of it contains summer pastures and 20.3 $km^2$ (17%) is forest. The only important river in this area is Sajadrood that originates in 3,713 m altitude and get out in 1,260 m altitude. The climatic condition is cold and mild mountainous with 7.504 mm annual rainfall. The lowest rate of temperature is in February and the highest rate is in August. The classification of the forest lands in the area was as plum, medlar, beech and thorn-apple. Additionally, the classification of pasture was as shrubbery-grassland.

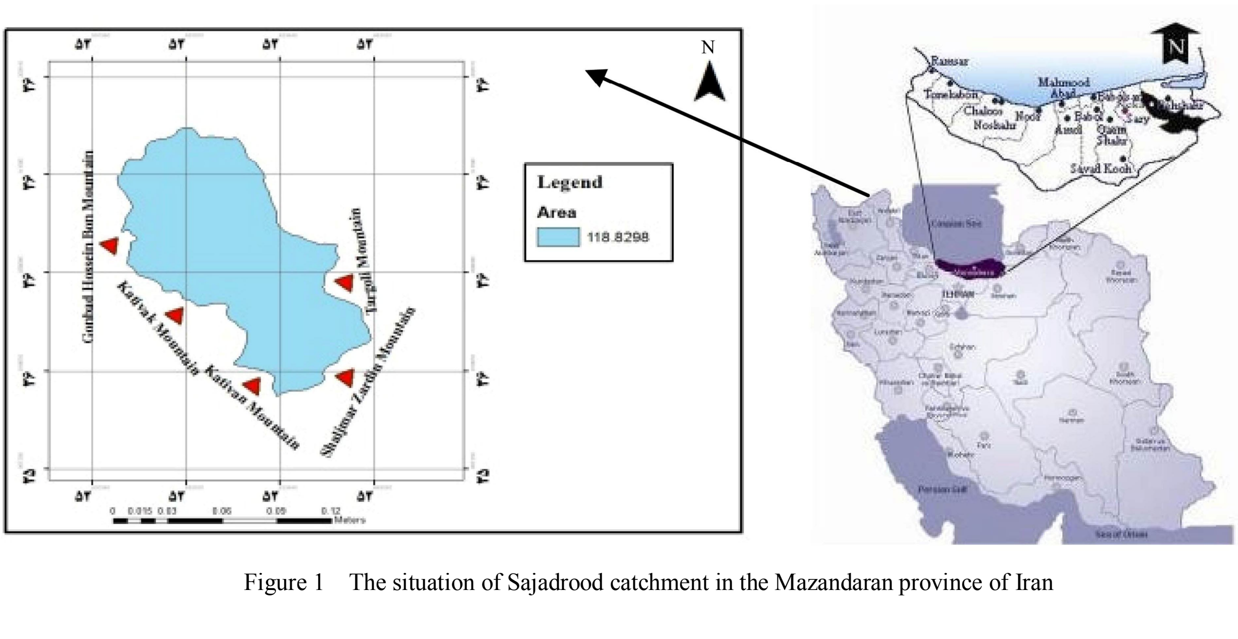


Figure 1 The situation of Sajadrood catchment in the Mazandaran province of Iran

### 2.1 Case study and data collection

A wide variety of physical and chemical characteristics can be used as indicators. Among factors that affect the soil properties, in this study six chemical and physical factors include: soil bulk density, acidity, moisture saturation percentage, soil texture, electrical conductivity and amount of organic carbon were considered. The study had been done in the summer of 2013. In each sites soil samples were extracted randomly in 10 replications, with 20×20×30 cm dimensions and at two depths include 0-10 cm and 10-20 cm (Celik, 2005). The target sites were selected in such a way that undamaged sites were beside the damaged sites. Additionally, soil classification and the materials had no difference (Hajabbasi et al., 2008) and in terms of physiography were in the same range (Rezaie Pasha et al., 2012). The soil samples were dried in 100℃ in 24 h then were beaten and passed through in a 2 mm sieve. The soil bulk density was measured using cylinder method (Blacke and Hartge, 1986). Also, soil type includes silt, clay and sand percentage was determined using hydrometric method (Bewketa and Stroosnijder, 2003). The amount of organic carbon was determined using walkly and black method (Walkly and Black, 1982; Schnitzer, 1982). The soil acidity and the electrical conductivity were measured using electrical PH meter and EC meter, respectively. Also amount of the neural materials was calculated using titration method; see Figure 2 and Figure 3 please.


Figure 2 Sampling area that include changing pasture to the farming land

a. 0-10 cm

b. 10-20 cm

Figure 3 Digging holes for soil sampling (0-10 cm and 10-20 cm depths)

### 2.2 Statistical analysis

After determining the soil physical and chemical changes in the laboratory, basic information were entered into Excel 2013 spreadsheets and to analyze the collected data, SPSS 21.0 software program, Levene test (equality or inequality of variances assumption) and independent T test (were used when there are two groups or lower than three groups) to compare the averages of factors were used.

## 3 Result and discussion

### 3.1 Soil bulk density

According to Table 1, there is no significant difference in amounts of surface and subsurface soil bulk density in two periods of usage in pastures and agricultural farms. In comparison with farms with the depth increase, soil bulk density increase in pastures. It can be justified by tillage practice and in dry land the soil become pores. The high amount of the soil bulk density in the farming land caused the limitation in the roots improvement (Dolan, 1992). Bewekta and Stroosnijder (2003) reported that eucalyptus soils had a statistically significant higher soil bulk density than soils under natural forests, cultivated lands and grazing lands but Breuer et al. (2006) and Hajabbasi et al. (2007) reported that there were no significant change in the soil bulk density due to the land use change in the Lahn-Dill highlands, Germany and south and southwest of Esfahan, respectively.

**Table 1 The comparison of soil physical properties in 0-10 cm and 10-20 cm depths**

| Variety | Depth, cm | | Site: 1 | | | | Site: 2 | | | | Site: 3 | | | | Site: 4 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Ave | df | F | Sig | Ave | df | F | Sig | Ave | df | F | Sig | Ave | df | F | Sig |
| Soil bulk density | 0-10 | Farm | 1.43 | 4 | 2.7 | $0.21^{ns}$ | 1.3 | 4 | 0.242 | $0.054^{ns}$ | 1.59 | 4 | 2.069 | $0.092^{ns}$ | 1.51 | 4 | 0.022 | $0.071^{ns}$ |
| | | Pasture | 1.52 | 2.093 | | 0.27 | 1.49 | 3.581 | | 0.061 | 1.68 | 2.375 | | 0.138 | 1.32 | 3.96 | | 0.071 |
| | 10 月 20 日 | Farm | 1.52 | 4 | 0.5 | $0.20^{ns}$ | 1.53 | 4 | 0.007 | $0.366^{ns}$ | 1.6 | 4 | 2.462 | $0.602^{ns}$ | 0.9 | 4 | 1.006 | $0.016^{*}$ |
| | | Pasture | 1.33 | 3.205 | | 0.22 | 1.48 | 3.86 | | 0.368 | 1.56 | 2.16 | | 0.625 | 1.41 | 2.778 | | 0.032 |
| Clay | 0-10 | Farm | | – | – | – | 8 | 4 | 2.118 | $0.042^{*}$ | 6.66 | 4 | 2.571 | $0.101^{ns}$ | 4.33 | 4 | 0 | $0.519^{ns}$ |
| | | Pasture | | – | | – | 4 | 2.249 | | 0.086 | 4.66 | 2.56 | | 0.139 | 4.66 | 4 | | 0.519 |
| | 10 月 20 日 | Farm | 10 | 4 | 0.7 | $0.76^{ns}$ | 7 | 4 | 0.4 | $0.007^{*}$ | 7 | 4 | 0 | $0.288^{ns}$ | 6.66 | 4 | 16 | 0.116 |
| | | Pasture | 9.66 | 4.448 | | 0.77 | 3 | 3.2 | | 0.013 | 6 | 4 | | 0.288 | 6 | 2 | | $0.184^{ns}$ |
| Sand | 0-10 | Farm | 52 | 4 | 1.3 | $0.020^{*}$ | 48 | 4 | 0.098 | $0.041^{*}$ | 58.66 | 4 | 2.528 | $0.018^{*}$ | 62 | 4 | 3.151 | $0.539^{ns}$ |
| | | Pasture | 62.66 | 2.758 | | 0.038 | 59 | 3.816 | | 0.043 | 73.66 | 2.22 | | 0.051 | 64.33 | 2.037 | | 0.571 |
| | 10 月 20 日 | Farm | 51 | 4 | 0.7 | $0.108^{ns}$ | 55 | 4 | 2.462 | $1.000^{ns}$ | 57 | 4 | 0.798 | $0.412^{ns}$ | 52.66 | 4 | 5.319 | $0.022^{*}$ |
| | | Pasture | 57.6 | 2.952 | | 0.133 | 55 | 2.16 | | 1 | 62.66 | 3.028 | | 0.428 | 60 | 2 | | 0.069 |
| Silt | 0-10 | Farm | 39 | 4 | 1.3 | $0.031^{*}$ | 44 | 4 | 1.326 | $0.062^{ns}$ | 35 | 4 | 1.241 | $0.014^{*}$ | 33.66 | 4 | 4.797 | $0.449^{ns}$ |
| | | Pasture | 26.6 | 2.758 | | 0.052 | 36.66 | 2.758 | | 0.089 | 22 | 2.624 | | 0.032 | 31 | 2 | | 0.49 |
| | 10 月 20 日 | Farm | 39 | 4 | 2.1 | $0.065^{ns}$ | 38 | 4 | 3.151 | $0.351^{ns}$ | 39 | 4 | 2.118 | $0.065^{ns}$ | 41 | 4 | 4 | $0.016^{*}$ |
| | | Pasture | 33 | 2.249 | | 0.11 | 41.66 | 2.037 | | 0.401 | 33 | 2.249 | | 0.114 | 34 | 2 | | 0.056 |
| Moisture saturation | 0-10 | Farm | 62 | 4 | 2.7 | $0.460^{ns}$ | 59.66 | 4 | 3.827 | $0.575^{ns}$ | 54 | 4 | 0.8 | $0.036^{*}$ | 63.66 | 4 | 1.248 | $0.004^{*}$ |
| | | Pasture | 66.6 | 2.093 | | 0.505 | 56.66 | 2.018 | | 0.604 | 46 | 2.941 | | 0.055 | 49 | 2.571 | | 0.015 |
| | 10 月 20 日 | Farm | 39.2 | 4 | 0.2 | $0.006^{*}$ | 56 | 4 | 0.731 | 0.633 | 50.33 | 4 | 1.247 | 4 | 61.66 | 4 | 0.643 | $0.001^{*}$ |
| | | Pasture | 63.3 | 3.489 | | 0.009 | 57.66 | 2.952 | | 0.642 | 55 | 2.6 | | 2.605 | 46.66 | 2.298 | | 0.002 |

Note: * indicate significance at 5%; ns: non-significant.

### 3.2 The soil texture

The percentage of sand, clay and silt indigents were measured and the results indicated that changing the land use from pasture to farming lands has significant difference in 5% level and silt at 0-10 cm level and also clay in both 0-10 cm and 10-20 cm have significant difference. The changes among silt, clay and sand during changing period shows that by changing the land usage the percentage of silt and clay in farms decreased but the sand percentage had increased. Bewekta and Stroosnijder (2003), Martinez-Mena et al. (2008) showed the same results in their studies. It can be justified that by decreasing the SOM and soil aggregate sustainability during the changes, amount of erosion increases and consequently during the erosion clay and silt are separated and move to the downstream area (Celik, 2005; Bewekta and Stroosnijder, 2003). These reasons in the site No. 4 with 5%-12% slope and mound humus in west direction is completely vice versa with other sites so that during the changes amount of clay at both of 0-10 cm and 10-20 cm depth have no significant difference but it increased with increase in depth in farming lands. Additionally, amount of silt and sand in subsurface farming land was higher than pasture. Planting vegetables in this site is the main reason that needs water and the irrigation led to tubing sand, clay and silt to farming land subsurface.

### 3.3 The moisture saturation percentage

Based on the results of the moisture saturation percentage in Table 1 the soil moisture saturation percentage in different application of the land is different. The soil moisture saturation percentage for farming land and pasture has significant difference and by increasing sand percentage and decreasing clay percentage the soil moisture saturation percentage decreases. In the site No 1 this percentage has no difference if that in pasture by increasing the depth it's higher than farming land. This difference is visible in 1-10 and 10-20 cm depths. By increasing the depth the moisture saturation percentage increases and there is no difference in pasture depths. In the site No. 2 there is no difference between two depths and kind of land using. Additionally, in the site No. 3 and 4 the moisture saturation percentage in farming lands was higher but there was no difference in two depths of farming land and pasture.

### 3.4 The amount of organic carbon

The results of the amount of organic carbon are presented in Table 2. The results of statistical analyses and average comparison for both of the 0-10 cm and 10-20 cm depth showed that the change in usage caused the amount of organic matter decrease. Generally, the vegetation, tillage operation, kind of land usage after the change (dry farming), the intensity and frequency of tillage operations, kind of planting crops, time of sampling and … are effective factors in increasing the SOM content based on the changes in the surveyed area. Although it seems that in the surveyed sites the vegetation in the intact pastures was moderately suitable but there is no decrease in organic matter, because the planting crop and fertilizing prevent to decrease the organic matter. Martinez-Mena et al (2008) reported that in the non-irrigated olive grove and abandoned agricultural field, the reduction in particulate organic carbon was proportionally greater than the decline in mineral-associated organic carbon. Additionally, Tiessen et al. (2003) observed that changes in organic carbon contents after deforestation strongly depend on soil type. In the literature, Kerna and jonson (1993), Paustian et al. (1997), Bear et al. (1994), Celik (2005), Chibsa and Ta'a (2009), Bowman and Reader (1990) and Tissen and Stewart (1983) found the same results.

**Table 1 The comparison of soil chemical properties in 0-10 cm and depths**

| Variety | Depth, cm | | Site: 1 | | | | Site: 2 | | | | Site: 3 | | | | Site: 4 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Ave | df | F | Sig | Ave | df | F | Sig | Ave | df | F | Sig | Ave | df | F | Sig |
| Organic carbon | 0-10 | Farm | 3.3 | 4 | 2.752 | $0.029^{*}$ | 3.37 | 4 | 0.634 | $0.057^{ns}$ | 3.05 | 4 | 0.702 | $0.004^{*}$ | 3.42 | 4 | 2.693 | $0.029^{*}$ |
| | | Pasture | 3.6 | 2.102 | | 0.073 | 2.31 | 3.107 | | 0.0742 | 1.5 | 3.023 | | 0.01 | 1.84 | 2.1 | | 0.074 |
| | 10 月 20 日 | Farm | 3.7 | 4 | 0.254 | $0.487^{ns}$ | 3.19 | 4 | 0.006 | $0.335^{ns}$ | 2.7 | 4 | 0.002 | $0.217^{ns}$ | 2.9 | 4 | 3.3 | $0.037^{*}$ |
| | | Pasture | 3.7 | 3.558 | | 0.492 | 2.27 | 3.955 | | 0.336 | 1.7 | 3.997 | | 0.217 | 1.69 | 2 | | 0.09 |
| Soil acidity | 0-10 | Farm | 7.1 | 4 | 1.432 | $0.625^{ns}$ | 5.84 | 4 | 3.071 | $0.001^{*}$ | 5.4 | 4 | 2.462 | $0.008^{*}$ | 4.84 | 4 | 1.873 | $0.030^{*}$ |
| | | Pasture | 6.9 | 2.532 | | 0.64 | 7.31 | 2.069 | | 0.013 | 6.7 | 2.16 | | 0.034 | 6.76 | 3.1 | | 0.043 |
| | 10 月 20 日 | Farm | 7.8 | 4 | 0.795 | $0.303^{ns}$ | 5.73 | 4 | 2.118 | $0^{*}$ | 5.47 | 4 | 1.147 | $0.029^{*}$ | 5.34 | 4 | 0.127 | $0.004^{*}$ |
| | | Pasture | 6.5 | 2.941 | | 0.324 | 7.33 | 2.249 | | 0.001 | 6.25 | 2.705 | | 0.052 | 6.29 | 3.7 | | 0.005 |
| Electrical conductivity | 0-10 | Farm | 0.3 | 4 | 1.142 | $0.940^{ns}$ | 0.29 | 4 | 2.462 | $0.534^{ns}$ | 0.2 | 4 | 3.758 | $0.029^{ns}$ | 0.16 | 4 | 0.273 | $0.539^{ns}$ |
| | | Pasture | 0.3 | 2.814 | | 0.941 | 0.27 | 2.16 | | 0.562 | 0.77 | 2.004 | | 0.273 | 0.17 | 2.2 | | 0.566 |
| | 10 月 20 日 | Farm | 0.3 | 4 | 0.032 | $0.890^{ns}$ | 0.275 | 4 | 0.022 | $0.555^{ns}$ | 0.21 | 4 | 2.294 | $0.704^{ns}$ | 0.23 | 4 | 0.795 | $0.061^{ns}$ |
| | | Pasture | 0.3 | 3.883 | | 0.89 | 0.3 | 3.956 | | 0.555 | 0.35 | 2.194 | | 0.445 | 0.14 | 3 | | 0.08 |

### 3.5 The soil acidity

Totally based on Table 2 it can be considered that the acidity of pasture is higher than farming land. At 1-10 cm depth of the farming land the acidity is higher than 10-20 cm depth. This difference is not visible in pasture. In the site No. 4 in comparison with the amount of the soil acidity in surface soil it shows that farming land had higher acidity rather than pasture but in subsurface soil this difference is higher in the pasture. Many important factors, such as rainfall, vegetation type and temperature can affect the soil acidity. Balesdent et al, (2000) and Tejada and Gonzalez (2009) has found that cultivation on farm lands led to the soil acidity increase.

### 3.6 The soil electrical conductivity

According to the amount of the moisture held by soil particles soil electrical conductivity varies. Table 2 shows the results of the electrical conductivity. The results indicated that there is no significant change in comparison of both of the 1-10 and 10-20 cm depths. Dolan et al. (1992) declared the same results. They results shows that the soil electrical conductivity varies in different soil depth.

## 4 Conclusions

Increasing land conservation requires soil fertility management within a broader framework of sustainable development (Smith, 2008). In recent years severe land-use changes to produce more agricultural commodities have occurred in the north of Iran and pastures are rapidly converted into agricultural farm. In this study we investigated on the influence of changing the use of pasture to farming lands on many important soil chemical and physical properties such as: soil bulk density, acidity, moisture saturation percentage, soil texture, electrical conductivity and amount of organic carbon in the Sajadrood catchment. Based on study results, following conclusions were drawn:

1) The results showed that the amount of soil bulk density, amount of organic carbon and the percentage of clay were increased in farming lands in comparison with pastures.

2) In pasture, with the depth increase, there is a reduction in acidity and percentage of the moisture saturation, but there is an increase in the amount of neutral substances and the percentage of clay, with the depth increase (10-20 cm).

3) The amount of physical and chemical change in farm lands by changing the use of land is lower than pasture.

4) According to the ecological importance of northern pastures of Iran, the results of this study showed that the need of more attendance to the study on ability, modify and change the land use in this region.

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