FULL LENGTH ARTICLE

Evaluation of Land Capability for Agriculture Using Geo-Spatial Technologies in the Upper Dhidhessaa Watershed, Blue Nile Basin, Ethiopia

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Abstract

Land is a limited resource characterized by complex competitions over its use. Land capability evaluation is an important tool for identifying the capability of land for agricultural and other uses. This study, therefore, aimed at evaluating land capability for agriculture in the Upper Dhidhessaa watershed of the Blue Nile basin of Ethiopia. The main sources of data of the study were secondary data obtained from Ministries and Agencies of the Federal Government of Ethiopia. Multi criteria evaluation technique was used to identify the land use capability classes and subclasses in the watershed. Data on land characteristics were weighted based on specific agricultural land classes using Storie Index rating. The principal limiting parameters such as texture, drainage, slope and stoniness were identified. These factors were used with the consideration that their effect on land is relatively permanent. Land use capability classification was carried out by matching the land characteristics and thus, five LU classes represent the watershed and GIS platform was used to produce land capability maps for both classes and units. Almost all or 99.9 percent of the watershed lies within capability class 1 to 4. This indicates that the study watershed is suitable for arable cropping, pastoral grazing or forestry. Specifically, 42.6 % of the watershed is categorized as class 1 land (i.e., excellent capability with none to least limitations). The study concludes that the land use capability classification provides information about both the degree of limitation and kind of problems involved for broad planning and conservation studies

Keywords: **/**Land capability/Land class/ Land unit/Land evaluation/Dhidhessaa Watershed/Ethiopia/

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1. Introduction

The function of land use planning is to guide the decisions on land use in such a way that the resources of the environment are put to the most beneficial use for human being, whilst at the same time conserving those resources for future (FAO, 1976). Land use planning thus requires land evaluation, i.e., a comparison of the benefits obtained or potentially obtainable and inputs required for different potential uses of land. Therefore, land evaluation has several components; it includes assessment of both the natural resources - physical land evaluation and socioeconomic aspects of the use of land. The whole process of land evaluation provides explanations as to how the land is sustainably used (Young, 1998). The explanations provided by land evaluation are considered as interpretations by Klingebiel & Montgomery (1961) quite long time ago and that notion still holds true. that interpretative actions by land use planners is the most significant contribution to land use planning.

The capability classification is one of a number of interpretive groupings made primarily for agricultural purposes. Capability is the inherent capacity of land to perform at a given level for a general use (FAO, 1976). Land capability classification evaluates the potential of land for general agricultural use involving current technology and agronomic management practices. On the other hand, land suitability evaluates specific land use system in which detailed statement about land use and management is carried out. Capability evaluation practice of land grew out of the agricultural land capability classification system adopted by the United States Department of Agriculture (USDA) (FAO, 1976). The method of land evaluation has helped in translating environmental data into terms of land use potential. The essence of land evaluation is to match land use with types of land. It basically answers two questions:

- We have an area of land; what is the best use to which it can be put?
- We wish to expand a kind of land use; where are the best areas on which to do it?

The evaluation process involved in this study aims to answer the first question – the best uses to which the land can be put. The planning objective in this case could be improving the living standard of an area and identifying priority areas for different kinds of development of a country (Young, 1998).

In this study, the capability units were identified based on similar soil types. Soils that were nearly alike in their suitability for plant growth and responses to management considered as one mapping unit. Thus, the assumption is that soils in the same unit are sufficiently uniform to produce similar kinds of cultivated crops and pasture plants; require similar management practices, conservation treatment and management under the same kind and condition of plant cover. Then principal limiting parameters were identified - texture, drainage, slope, stoniness and soil depth being the significant ones. These factors were identified and used with the consideration that their effect on land is relatively permanent.

In this classification, lands are grouped into seven classes according to their potentialities and limitations for agricultural use depending on inherent soil physical characteristics (Dumanski, et al., 2010). The first three classes are considered capable of sustaining production of a wide range of common cultivated crops. Range of crops decreases from Class 1 to 3. The fourth class is marginal for sustained arable cultivation and is capable of producing only a narrow range of crops, while the fifth class can be used only for permanent pasture and/or hay (or a single specialty crop) - extremely narrow range of cropping possibilities. Whereas the sixth can only be used for natural sustained grazing, while the seventh class is considered incapable of using for cultivated crops or grazing.

Land use capability (LUC) classification is carried out by matching the land characteristics with the requirements of the envisaged land utilization types. Then, land indices were produced to classify the land characteristics into classes and units. The functioning of these approaches is effectively possible using GIS platform. Using GIS, the evaluation process is run to produce land capability maps for both classes and units. The output maps could play major role for possible land use change to the land's best potentials displayed by the classes and tackle management problems outlined in the subclasses. However, further social and economic evaluations are quite essential.

2. Review Literature

2.1. Concepts and Definitions

2.1.1. Land Capability and Land Suitability

Land capability and land suitability are mistakenly taken as synonymous, but these are terms conceptually and practically different in land evaluation studies. Land capability refers to the ability of the land to sustain a type of land use permanently without causing damage (Beek, 1978). That is, it refers to the inherent ability of the land, based on soil and terrain attributes, to produce common crops. Land suitability, on the other hand, denotes the ability of a portion of land to tolerate the production of specific crops in a sustainable way, based on land attributes in conjunction with other social and economic attributes or factors (FAO, 1976; Rabia, 2012).

2.1.2. Land Capability Evaluation and Land Capability Assessment

Effectively addressing the land's ability to produce is very important for maximum utilization of the potential of the land. For agrarian country like Ethiopia, it is of paramount importance as the country's food production and food security requires spatial analytical and optimization methods that can accurately assess the capability and suitability of available lands for current and future food production.

Land capability evaluation is a process of evaluating a given land's quality according to its capability for sustainable land use (Rossiter, 1996). The process characterizes and appraises land development units from general point of view without taking the kind of its use or specific crops into consideration.

Land capability assessment, which follows a similar approach to land capability evaluation, is a method of determining if a parcel land can sustain a specific use without being degraded over long period of time (Van Gool, Tille, & Moore, 2005). It takes into account the physical attributes of the land (geology, soil, slope, etc.) and other factors such as climate, erosion hazard, and land management practices which determine how that land can be used, without being destroyed, for sustainable agricultural activities. It also takes into account limitations that may affect agricultural use, for example, stoniness, salinity, drainage, and etc. Therefore, land capability assessment is based on the permanent biophysical feature of land and does not consider the economics of agricultural production such as – distance from markets, social or political factors.

2.2. Approaches to Land Capability Classification

There are various approaches to land capability classification used by scholars and institutions in different countries since 1930s. The first land capability classification was developed by the United States Department of Agriculture's (USDA) Soil Conservation Service (SCS) (presently known as Natural Resource Conservation Service) in the late 1930s and early 1940s whose objective was evaluating appropriate uses of farmland and making recommendations on soil conservation practices (Dumanski, et al., 2010). A three-level classification consisting of capability class, subclass, and unit have been started to be used during that time.

Another significant land capability classification approach was the Canada Land Inventory which was one of the most successful adaptations of the land capability classification system of the US. It was a major program designed to provide a comprehensive, standardized assessment of land capability to support defined land-based activities in the country (Rees, 1977).

In the 1960s another notable land capability classification system was developed by USDA and it was known as the US Department of Agriculture method. Most of the land capability classification systems and mapping are an adaptation of this method. Therefore, it is indisputably the most commonly used land classification system in the world (Atalay, 2016).

The United Nations Food and Agricultural Organization (FAO) Framework for Land Evaluation, through widespread adoption and adaptation, has emerged as an international standard for land evaluation. The approach consists four recognized categories, namely *orders*, *classes*, *subclasses* and *units*. Each category retains its meaning with respect to any classification, whether of 'present' suitability, 'potential' suitability, the classification of 'provisionally-irrigable' land, or of 'irrigable' land (FAO, 1976; FAO, 1984).

Recently, another approach to land capability classification was introduced by Atalay (2016) , who asserted that up to now the criteria that are taken into consideration in the land capability classification are topography especially slope and soil properties that may not suit to every environment. Therefore, the new system suggests, particularly in mountainous countries or regions, topographic or geomorphic units, climate and parent material to be taken into consideration to establish land capability classification. The result of the study conducted in Turkey found seven land capability classes whereas, the subclasses were determined according the parent material properties that mostly outcropped on the mountainous areas (Atalay, 2016).

As empirical evidences in literature show, land basically has different abilities to support a specific use that can be determined by conducting land capability classification (Montgomery, Dragićević, Dujmović, & Schmidt, 2016). Hence, land capability classification involves land valuation with the systematic components and grouping into categories based on the nature of potentials and constraints in its use (Klingebiel & Montgomery, 1961). In other words, determination of land capability classes depends on the nature of limiting factors.

In capability system soils are generally grouped at three levels namely: capability class, sub-class and unit. Capability class is the broadest category in the land capability classification system defined and grouped from class 1 to 8, with increasing limitations on land use and the need for conservation measures and careful management. Only information concerning general agricultural limitations in soil use is obtained at the capability class level. Capability subclasses, on the other hand, refer to soil groups within one class. A capability unit is a grouping of one or more individual soil units having similar potentials and continuing limitations or hazards.

The Storie rating system is an index for numerical rating of soils and is used to express numerically the relative degree of suitability, or value of a soil for general agriculture. The rating is based on soil characteristics only and is obtained by evaluating specific soil factors (Maw, 2016). In the Storie Index rating method, two major approaches can be differentiated: *parametric* systems based on a numerical correlation between crop performance and key land attributes and *categorical* systems which classify the land into units with different use potentials according to the number and extent of physical limitations to crop growth (Li, Messina, Peter, & Snapp, 2017).

2.3. The Role of GIS and Remote Sensing in Land Capability Evaluation

Studies show that with increasing pressure on natural resources due to the rising human population, Geographic Information Systems (GIS) and remote sensing technologies have been providing newer dimensions to monitor and manage land and soil resources for their effective utilization (Rabia, 2012; Atalay, 2016; and Montgomery, Dragićević, Dujmović, & Schmidt, 2016). Remote sensing technology, specifically, has become a viable tool for characterization and monitoring of soil resources due to the fact that the synoptic and repetitive coverage of satellites over large areas particularly inaccessible terrains makes fieldwork easier and data acquisition faster. Remote sensing technology also greatly assists in resource monitoring to the extent of precisely delineating soil boundaries (Kasthuri & Sivasamy, 2013).

GIS technologies are very important to analyze the share of factors that influence land use or limitations, as well as to produce thematic maps in digital formats as databases in land capability studies. In this manner integrated use of GIS and remote sensing technologies support decision making in identification and prioritization of land's potential for agriculture (Selamyihun, Mengistie, & Tezera, 2009; Girma & Kenate, 2017).

2.4. Previous Studies in Ethiopia

There are various studies conducted on land suitability assessment in various parts of the world. Land capacity assessment on the other hand has been scarcely studied both at the local and global scales. The lion's share of works done so far on this issue goes to USDA and FAO.

Land suitability for agriculture is a very important piece of information for agricultural development and future planning. Based on that, a land suitability assessment for agricultural purpose has been conducted in Kilte Awulalo, Ethiopia to help decision makers and agriculture development planners. The results showed variations in land suitability for different crops in the study area. The study found that only 7% of the study area showed no limitations for agricultural crops while a total of 67% of the study area was suitable for rain fed, irrigated agriculture and open vegetation growth (Rabia, 2012).

In a study conducted by Mengistie, Selamyihun and Tezera (2009) on a GIS based agricultural land suitability study for Target Crops in Ethiopia, it was indicated that GIS techniques have become very useful approach which can offer various opportunities to manage the land and care more efficiently. The study also underlines the fact that, GIS techniques can offer range of possibilities to assist land use in a sustainable way. A GIS based land capability classification for agriculture conducted in Gumay district of in Jimma Zone, Southwest Ethiopia indicated that 33.77% of the land in the district fall under class I; 39.67% categorized under class II; 7.65% fall under class III; 18.86% fall under class IV and only 0.05% of the land classified under class VI, which is not suitable for annual crop cultivation, and hence, should be under pasture, bush or tree cover (Girma & Kenate, 2017). Recognizing several land evaluation studies and the contributions of GIS platform in such studies would necessitate carrying out research at watershed level for thorough evaluation of the land and efficient planning. Therefore, the present study would provide a significant contribution for planners and development agents involved in land resources management to properly utilize the available land resources.

3. Materials and Methods

3.1. The Study Area

The study area is located in Dhidhessaa Watershed - Blue Nile Basin of Ethiopia. Dhidhessaa watershed drains three administrative zones of Oromia National Regional State of Ethiopia –Jimma Zone (in the most upper and middle part), Illubabor Zone (in the middle part) and East Wollega (in the lower part down to its confluence to the Abay River). Since the watershed covers large expanse of land, about 5.4 percent of Blue Nile basin, and crisscrosses several administrative units, this study focused on the upper part of the watershed (Regional Atlas of Oromiya , 1997; Oromia BoFED, 2012). Hence, Upper Dhidhessaa watershed (here after the watershed) is located between 7°42'8" to 8°15'27"N and 36°2'3" to 36°53'39"E (Fig.1). The watershed covers an area of 3770 km^2. Yebu, Urgessa, Temssa, Dabana, Indris, Anger and Tato rivers are some of the dozen tributaries of the Dhidhessaa River system.

The mean annual rainfall of the watershed is 1800mm, and its mean annual temperature is 20°C. The bimodal *belg*/*kremt* (short rains/long rains) pattern is most noticeable in the watershed, giving more rainy months of the year.

The watershed is characterized by the production of maize, sorghum and oil crops. Therefore, agriculture - crop and livestock production provides a major source of livelihood in the study area. Cereal crop sales and cash crop production and sales almost equally dissect the watershed, where northern and western part of the watershed is dominant cash crop producing area, whereas the eastern part is dominated by cereal crop production. In terms of geology, the tertiary volcanic series (dominantly basalt deposit) dominates the western half of the area and lower complex (Precambrian) granite dominates the land form of the study watershed (Oromia BoFED, 2012).

There are fourteen *Woredas* in the watershed out of which about 55 percent of the area of the watershed is made up of Dedesa, Gomma and Setema *Woredas*. These *Woredas* comprise 20%, 19% and 16% of the area respectively. Only Gumay *Woreda* has its entire area in the watershed (Oromia BoFED, 2012).

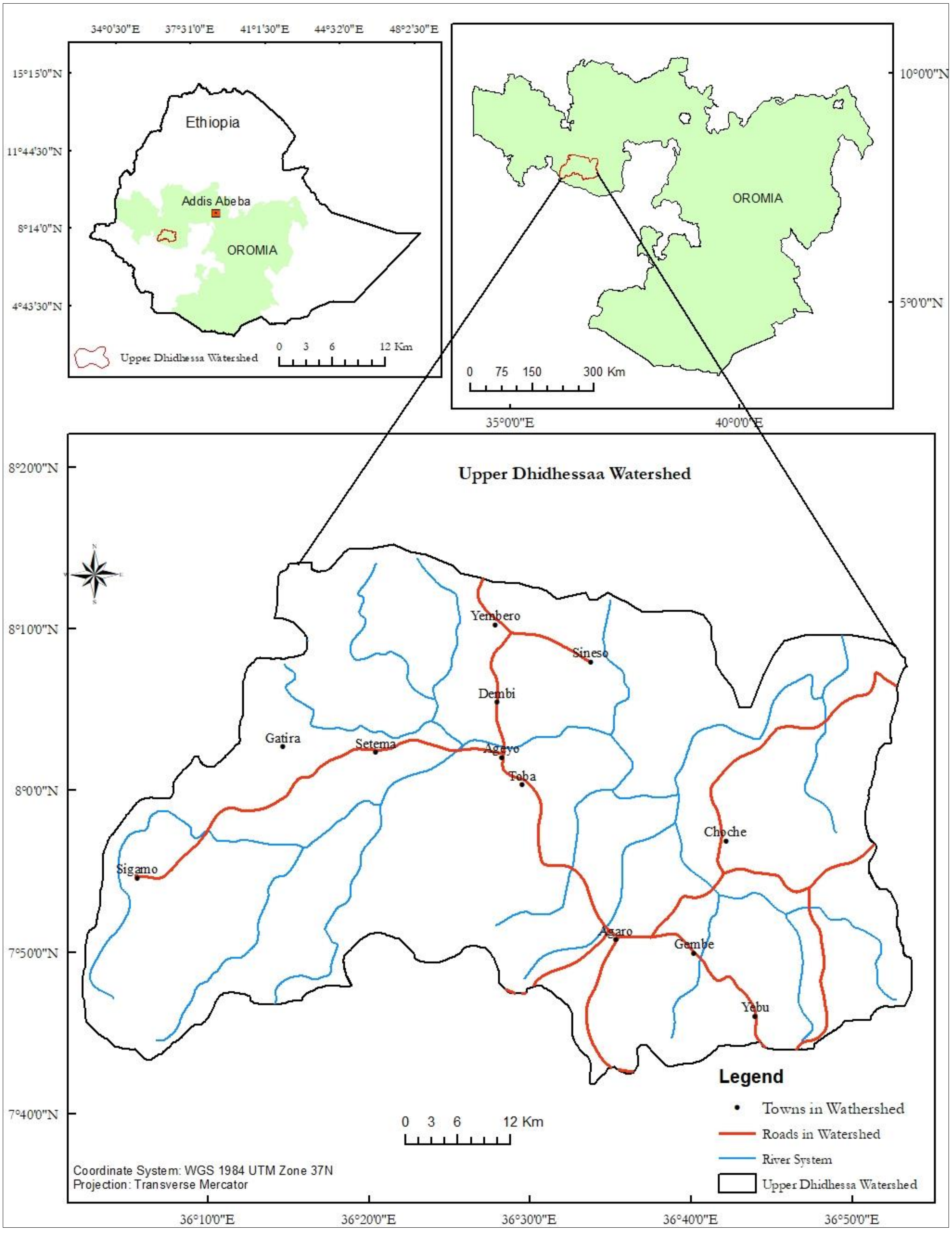

***Figure 1*:** Location Map of the Study Area (Source: Compiled from EthioGIS)

In terms of land use, the watershed is dominated by disturbed high forest that accounts about 45 percent of the watershed, and followed by dense mixed high forest and grassland which each covers 25 percent and 17 percent respectively (Fig. 2).

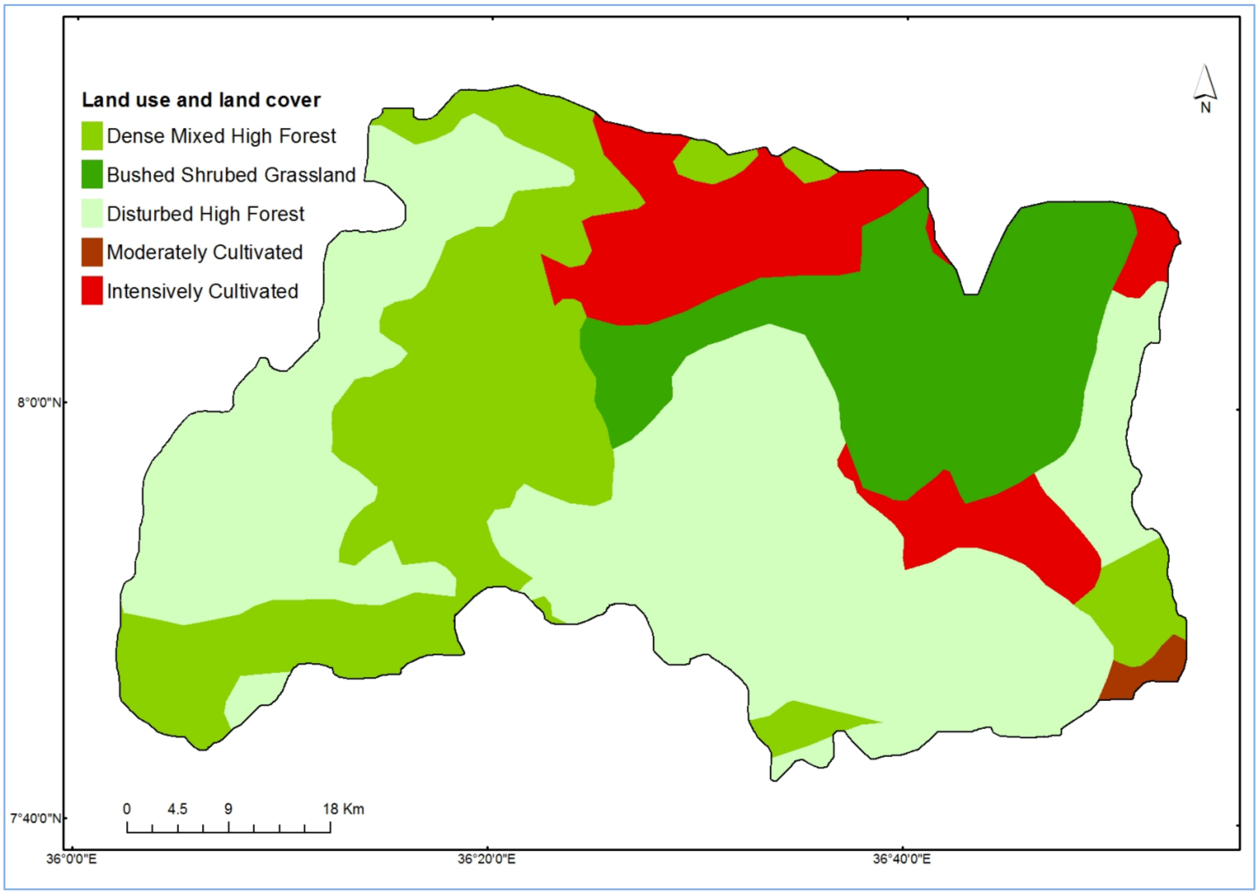

Figure 2**:** Land Use and Land Cover of the Watershed

3.2. Data Types and Sources

The intention of this study was to forward suggestions on the current methodological gap in land use planning in the study area and beyond. Hence, this study can assist rural land use planning by identifying areas with similar sets of potentials and limitations for land use through basic environmental parameters. These essential parameters in defining land evaluation classes are physical properties of the land and its limitations. Therefore, data for the land evaluation, particularly on edaphic properties of the land was obtained from Ministry of Agriculture of Ethiopia. Whereas climatic data for temperature class of the watershed was obtained from National Meteorological Agency of Ethiopia, and drainage class derived from data obtained from Ministry of Water Resources of Ethiopia. Additional sources of data used in the display of spatial boundaries of Ethiopia and the study watershed were obtained from EthioGIS database from the Ethiopian Mapping Agency.

3.3. Method of the Study

The objective of this study was to evaluate land capability by mapping areas that are best to use for agriculture vis-à-vis the present land use in the Upper Dhidhessaa Watershed. Whenever such study is carried out, two major approaches can be differentiated: **parametric** systems based on a numerical correlation between crop performance and key land attributes, and **categorical** systems which classify the land into units with different use potentials according to the number and extent of physical limitations to crop growth (FAO, 1984). Therefore, to attain the objective of the study the choice of method and tool is very essential. To this end, the latter method was chosen for its appropriateness for the researchers' context and availability and access to data, i.e., multi-criteria evaluation methods in the GIS workstation were used (Fig. 3).

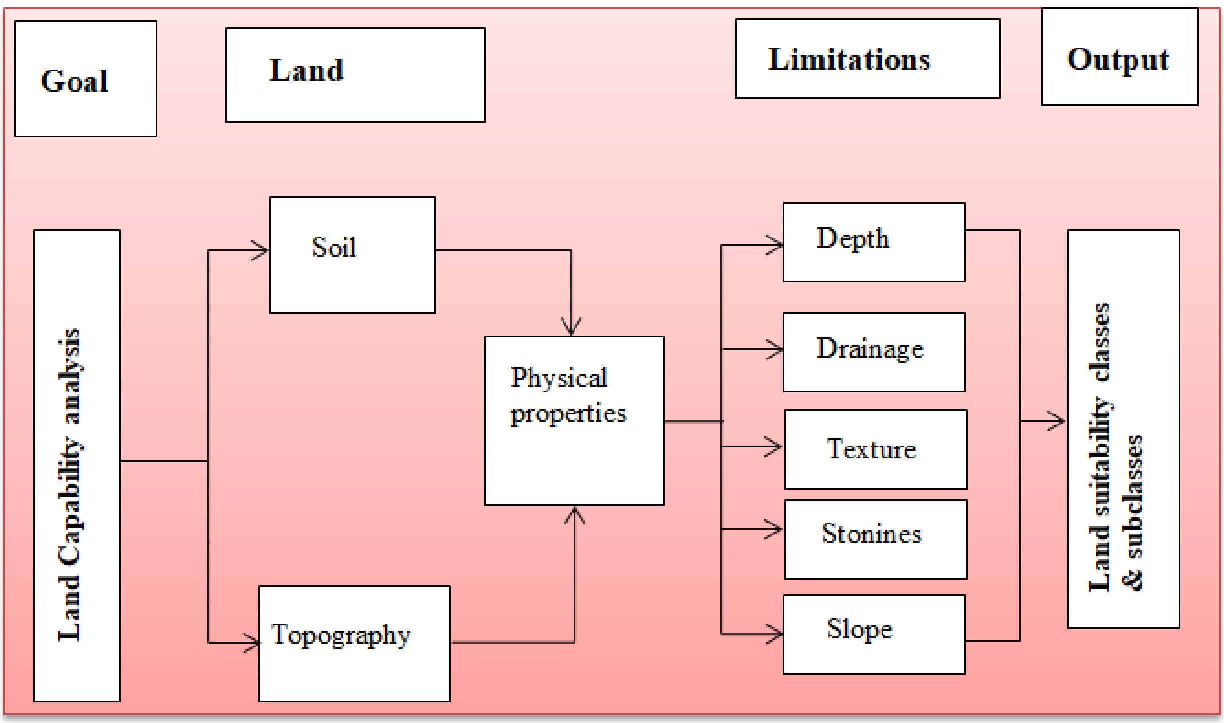

***Figure 3*:** Methodological Flowchart

Accordingly, the final goal was first set to identify land use capability classes and subclasses for the entire watershed where maps that show LUC were produced.

Data on land characteristics were weighted based on specific agricultural land classes using the rating table obtained from (WME, 2012) using **Storie Index** (Storie, 1978). The index is based on soil characteristics that govern the land's potential utilization and productive capacity. Then the weighted values were used in Storie Index (Storie,1978) in (UCANR, 2008) for the computation of capability units by the formula:

$$SI = \left[\frac{A}{100} x \frac{B}{100} x \frac{C}{100} x \frac{D}{100} x \frac{E}{100} \right] x 100$$

Where; **SI** is **Storie index**

A = rating of soil texture

B = rating of soil depth

C = rating of slope

D = rating of drainage

E = rating of stoniness

Table 1: Storie Rating Table

Final Grading	Capability Class	Rate	Limitations
80 – 100	Class 1	Excellent	None to slight
60 – 80	Class 2	Good	Slight
40 – 60	Class 3	Fair	Moderate
20 – 40	Class 4	Poor	Severe
10 – 20	Class 5	Very poor	Very severe
<10	Class 6	Non-agricultural	Extremely severe

Source: (UCANR, 2008)

Based on the final grade shown in Table 1, the capability classes and units were identified from the index and mapped using the GIS platform (Fig. 5 and 6; Appendix 1). The LUC Class is the broadest grouping of the capability classification. It is an assessment of the land's capability for use, while taking into account its physical limitations and its versatility for sustained production. The LUC displays different degree of limitation and versatility of land use (Table 2); as the classes increase the limitation to use the land increases, hence this makes the management of higher classes more difficult. Similarly, the general use of the land for multiple purposes, that is the versatility of the land, decreases with increasing land utilization classes. This indicates that classes found within the range of 1 to 4 are multiple use land.

Table 2: LUC and Degree of Limitation and Versatility of Use

Increasing limitation to use	LUC Class	Arable cropping suitability	Pastoral grazing suitability	Production forestry suitability	General suitability	Decreasing versatility of use
	1	High	High	High	Multiple use land	
	2					
	3					
	4	Low				
	5	Unsuitable				
	6					
	7		Low	Low		
	8		Unsuitable	Unsuitable	Conservation land	

4. Identification of Land Mapping Units

Land mapping units (LMU) used for mapping purpose in this study was based on major soils of the study area (Fig. 4). As Ann and Erik (2014) state, land units are generally taken from soil survey maps since they characterize homogenous and more or less stable land use of the area. Therefore, thirty-eight mapping units were identified in the study area on which other overlays were made to produce the final land capability classes and units map.

5. Results and Discussion

5.1. Capability Classes of the Watershed

According to Table 3, six LUC classes represent the watershed. Almost all or 99.9 percent of the watershed lies within capability class 1 to 4. This indicates that the study watershed is suitable for arable cropping, pastoral grazing, or production forestry. Specifically, 42.6 percent the watershed is categorized as class 1 land. In the meantime, Fig.5 shows the spatial distributions of these capability areas. Accordingly, large western part and patches of central part of the watershed lie under this category of land.

Table 3: Area and Capability Classes of the Watershed

Capability Classes		
LUC Class	**Area [Ha]**	**Percent of total area**
Class 1	165295	42.6
Class 2	55168	14.2
Class 3	141820	36.6
Class 4	25089	6.5
Class 6	398	0.1
Total	**387770**	**100.00**

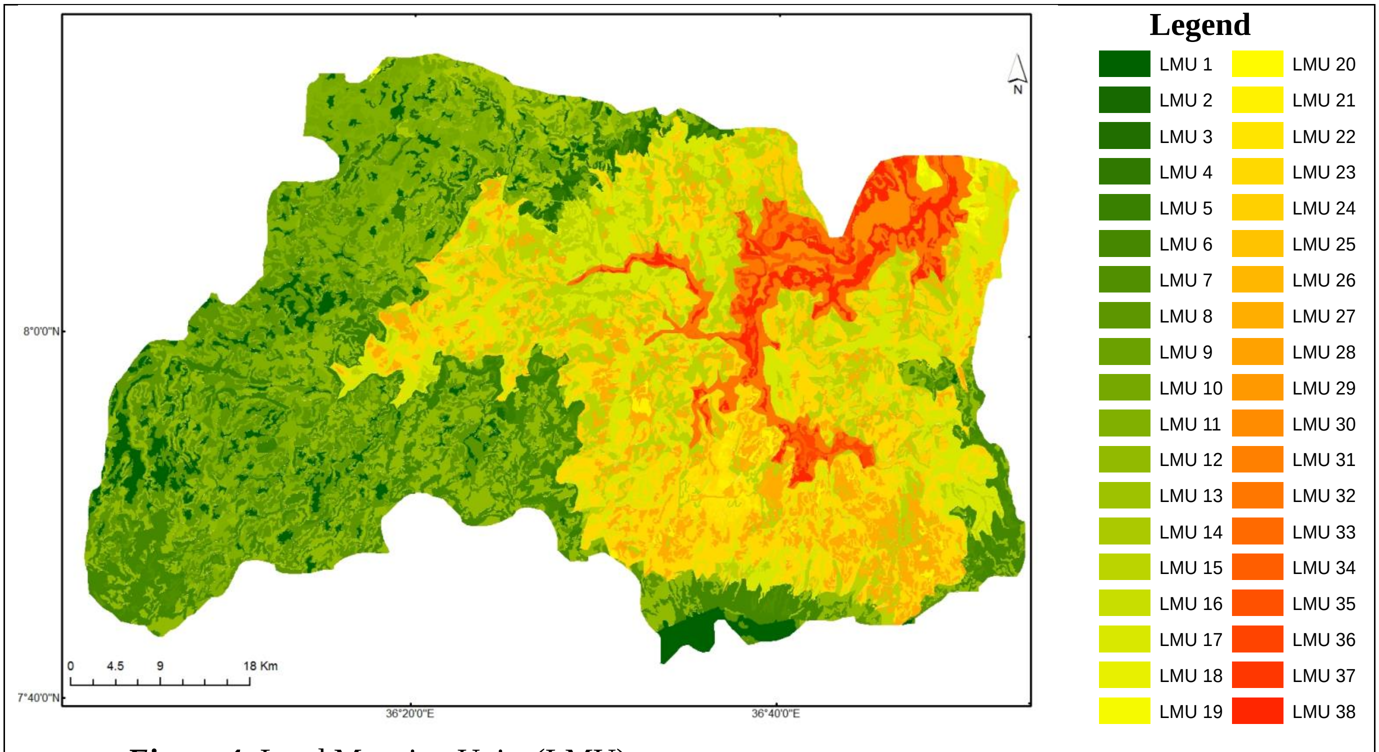

Figure 4: Land Mapping Units (LMU)

Soils in **Class 1** have about the same responses to systems of management of common cultivated crops and pasture plants. They might have been adapted to the same kinds of common cultivated crops and pastures plants, and require similar alternative systems of management for crops.

Soils in this class (**Class 1**) are suited to a wide range of plants and may be used safely for cultivated crops, pasture, range, woodland, and wildlife. The soils are nearly level and erosion hazard (wind or water) is low. They are deep, generally well drained, and easily worked. They hold water well and are either fairly well supplied with plant nutrients or highly responsive to inputs of fertilizer. They are productive and suited to intensive cropping.

Soils in class 1 that are used for crops need ordinary management practices to maintain productivity - both soil fertility and soil structure. Such practices may include the use of one or more of the following: fertilizers and lime, green-manure crops, conservation of crop residues and animal manures, and sequences of adapted crops.

As shown in Table 3, LUC **class 2** covers about 14 percent of the watershed. As also depicted on the map on Fig.5, it is located in the western half of the watershed. Soils in class 2 require careful soil management, including conservation practices, to prevent deterioration or to improve air and water relations when the soils are cultivated. The limitations are few and the practices are easy to apply. The soils may be used for cultivated crops, pasture, range, woodland, or wildlife food and cover.

Soils in class 2 may also require special soil conserving cropping systems, soil conservation practices, water control devices, or tillage methods when used for cultivated crops. For example, deep soils of this class with gentle slopes subject to moderate erosion when cultivated may need one of the following practices or some combination of two or more: **terracing**, **strip cropping**, **contour tillage**, **crop rotations** that include grasses and legumes, vegetated water disposal areas, cover or green-manure crops, stubble mulching, fertilizers, manure, and lime. The exact combinations of practices vary from place to place, depending on the characteristics of the soil, the local climate, and the farming system.

LUC class 3 is the second largest in the watershed; it covers about 37 percent of the total area (Table 3). As shown on map in Fig. 5, it covers large areas of the central and eastern part of the watershed. Soils in this class (class 3) have more restrictions than those in class 2 and when used for cultivated crops, the conservation practices are usually more difficult to apply and to maintain. They may be used for cultivated crops, pasture, woodland, range, or wildlife. Limitations of soils in class 3 restrict the amount of clean cultivation; timing of planting, tillage, and harvesting, choice of crops, or some combination of these limitations.

LUC class 4 covers small portion of the watershed; that is about seven percent of the watershed. It is located in the upper part of the river in southern fringes of the watershed. The restrictions in use for soils in class 4 are greater than those in class 3, and the choice of plants is more limited. When these soils are cultivated, more careful management is required and conservation practices are more difficult to apply and maintain. Soils in class 4 may be used for crops, pasture, woodland, range, or wildlife food and cover. Soils in this class may be well suited to only two or three of the common crops.

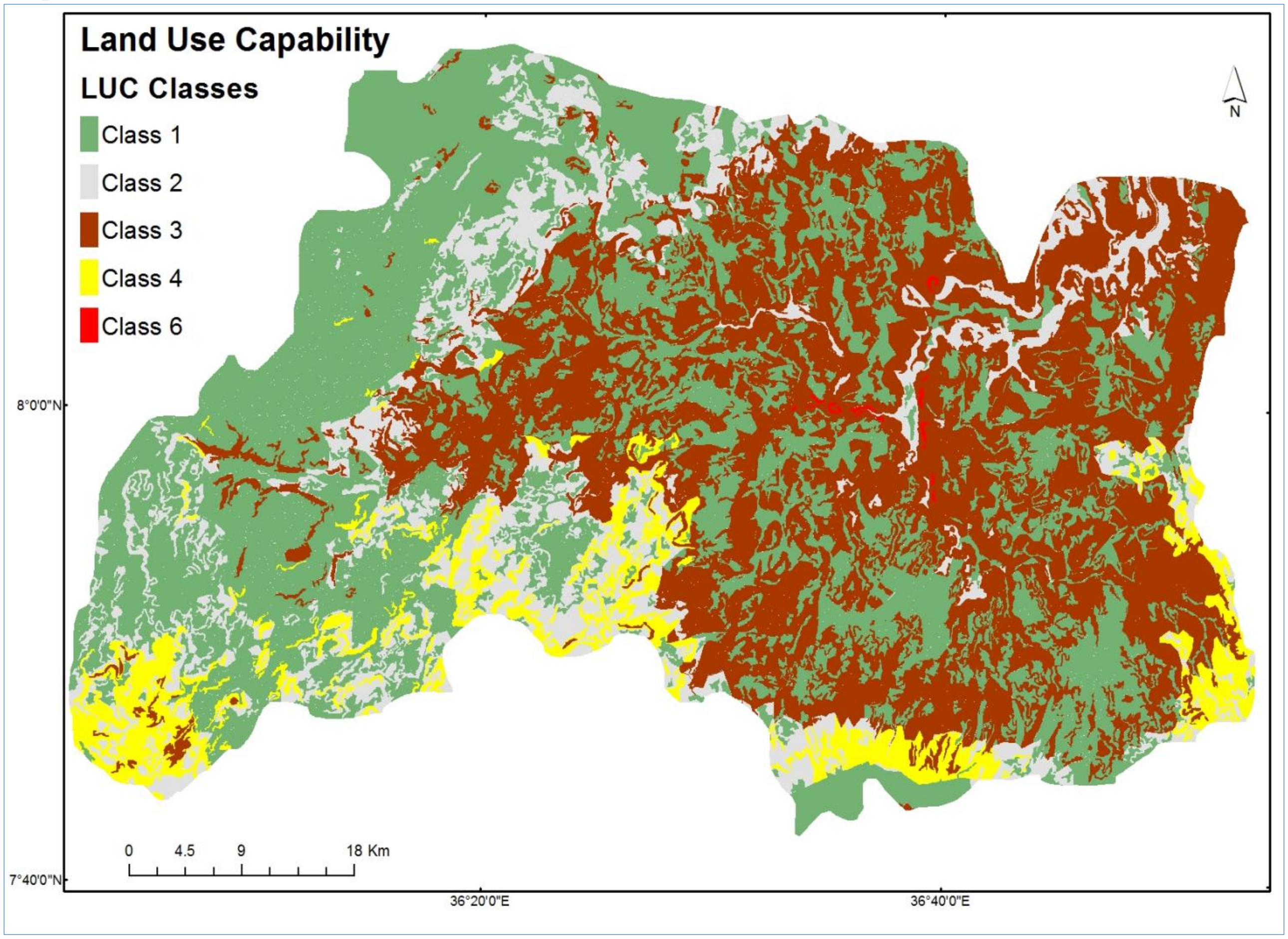

***Figure 5*:** Land Use Capability Classes in the Watershed

LUC class 6 covers very small portion of the watershed or only 0.01 percent of the total area. It is found in part of the watershed where shallow soil depth in a rugged part of the watershed was the main limitation. Soils in class 6 have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife food and cover. Physical conditions of soils placed in class 6 are such that it is practical to apply range or pasture improvements, if needed, such as seeding, liming, fertilizing, and water control with contour furrows, drainage ditches, diversions, or water spreaders.

5.2. Capability Subclasses in the Watershed

Land use capability subclass provide useful information about the degree of **limitation** and kind of **problem** involved for broad program planning, conservation need studies, and similar purposes. Furthermore, the information is useful for land use planning and for determining conservation and management requirements. The limitations appear to be significant after LUC class 2, and hence Table 4 excludes both class 1 and class 2, which cover 56.8 percent of the watershed. However, for the purpose of comparison LUC class 1 is depicted on Fig. 6 below.

In the study watershed, the most serious limitation is posed by soil **texture** (T). That is, the limitation by texture accounted about 18 percent of the area (Table 4). The effect of texture indicates that the land areas are adversely affected by lack of water due to inherent soil characteristics.

Table 4: Capability Subclasses in the Watershed

Capability Subclasses		
LUC Subclass	**Area [Ha]**	**Percent of Total Area**
3D	3497	0.90
3LD	42343	11.00
4L	44223	11.40
4LT	45127	11.60
5L	8180	2.11
5T	2590	0.67
5W	5428	1.40
6T	474	0.12
7T	70613	18.20
Total	**222475**	**57.40**

The second largest single limitation in the watershed is **slope** (L); it constitutes 11 percent of the limitations in the area. This subclass indicates landscapes with slopes steep enough to incur a risk of water erosion or to limit cultivation. **Depth of topsoil** (D) and **drainage (**W**)** pose little limitation, 0.9 percent and 1.4 percent respectively, in the watershed indicating that the area has deep soil and no significant water logging problem. Meanwhile, no serious management problem can be posed by **stoniness** (S) in the watershed as all the land mapping units are less than 15 percent slope class.

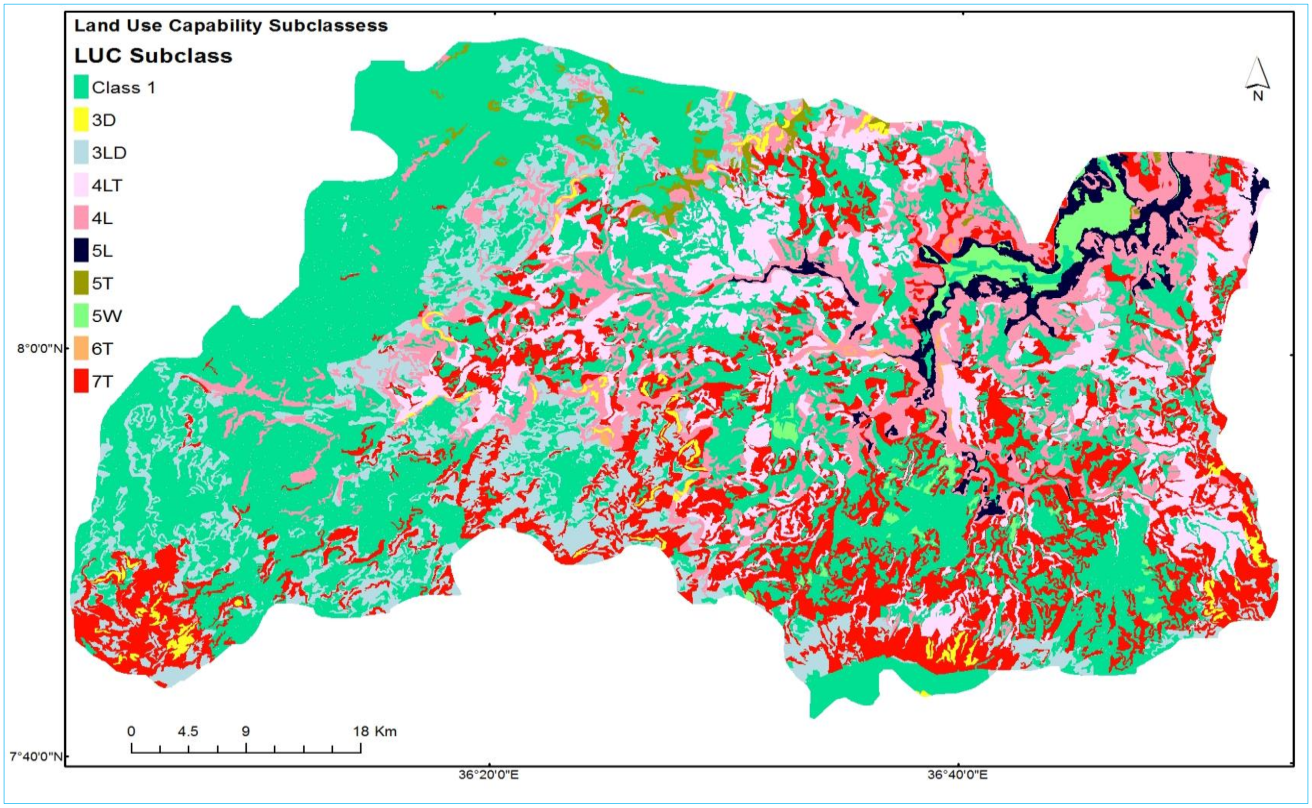

Figure 6**:** Land Use Capability Subclasses in the Watershed

5.3. LUC Classes vis-à-vis Land Use Land Cover in the Watershed

Land capability classification carried out in the watershed reveals that 99.9 percent of the watershed is capable of arable cropping. However, the current practice of land use in the watershed is dominated by disturbed high forest that accounts about 45 percent of the area followed by dense mixed high forest with 25 percent of the watershed (Fig. 2). Cultivated land accounts 12 percent of the watershed (Table 5). This indicates that forestry has dominated the area. The dominance of forest as major land use in the study watershed could be because of coffee production of the area.

Table 5: Land Use and Land Cover of the Watershed

Land Use Land Cover		
LULC Type	**Area [Ha]**	**Percent of Total Area**
Bushed shrub grassland	65795	16.97
Dense mixed high forest	97867	25.23
Disturbed high forest	176308	45.47
Intensively cultivated	45763	11.80
Moderately cultivated	2037	0.53
Total	**387770**	**100.00**

6.Conclusion and the Way Forward

Land use capability classification provides useful information about both the degree of limitation and kind of problem involved for broad program planning, conservation need studies, and similar purposes. Furthermore, the information is useful for land use planning and for determining conservation and management requirements. Therefore, the comparison of land use and land utilization capability classes of upper Dhidhessaa watershed gives indication that the area has huge potential for arable agriculture. Given the 42.6 percent of the watershed lies within class 1 land, implication for management and tackling limitations is not going to be difficult task.

However, certain limitations were also identified in the study watershed. The most serious limitation is soil texture (T) and it accounted about 18 percent of the area. Basic management practices such as: terracing, strip cropping, contour tillage, crop rotations that include grasses and legumes, vegetated water disposal areas, cover or green-manure crops, stubble mulching, fertilizers, manure, and lime could reduce the limitations and large area of the watershed can be used for sustained arable cropping. The study also shows that to make wise and rational land use decision making, further social and economic evaluations as well as conservation considerations are required.

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Appendix 1: Limitations and Capability Classes

Slope Class	Texture Class	Depth Class	Ston. Class	Drainage Class	Capability Class	Subclass
L1	T2	D1	S1	W2	Class_1	2TW
L1	T4	D1	S1	W5	Class_3	5W
L1	T5	D1	S1	W2	Class_1	5T
L1	T3	D1	S1	W1	Class_1	3T
L4	T6	D3	S1	W1	Class_3	6T
L4	T5	D3	S1	W1	Class_3	5T
L4	T3	D2	S1	W1	Class_2	4L
L4	T7	D2	S1	W1	Class_4	7T
L4	T4	D2	S1	W1	Class_3	4LT
L4	T4	D2	S1	W1	Class_2	4LT
L4	T2	D3	S1	W1	Class_3	4L
L4	T2	D3	S1	W1	Class_3	4L
L2	T5	D2	S1	W1	Class_1	5T
L2	T3	D1	S1	W2	Class_1	3T
L2	T3	D1	S1	W2	Class_1	3T
L2	T3	D2	S1	W2	Class_1	3T
L2	T5	D1	S1	W2	Class_1	5T
L2	T2	D2	S1	W1	Class_1	2LT
L2	T3	D1	S1	W2	Class_1	3T
L2	T5	D1	S1	W2	Class_1	5T
L2	T4	D1	S1	W3	Class_3	4T
L2	T5	D1	S1	W4	Class_2	5T
L2	T7	D1	S1	W2	Class_3	7T
L2	T2	D1	S1	W2	Class_1	2LTD
L2	T5	D2	S1	W3	Class_2	5T
C5	T2	D3	S1	W1	Class_3	3D
C5	T2	D2	S1	W1	Class_3	5L
C5	T6	D5	S1	W5	Class_6	6T
L1	T4	D1	S1	W5	Class_3	5W
L2	T2	D1	S1	W1	Class_1	3L
L2	T2	D3	S1	W1	Class_2	3LD
L2	T7	D1	S1	W1	Class_3	7T
L2	T5	D1	S1	W1	Class_1	5T
L2	T3	D2	S1	W1	Class_1	3LT
L2	T7	D1	S1	W2	Class_3	7T
L2	T7	D2	S1	W1	Class_3	7T
L2	T7	D1	S1	W2	Class_3	7T
L4	T3	D3	S1	W1	Class_3	4L