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Immunizing Job Recommender System

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Abstract

Artificial Immune Systemis a novel computational intelligence technique inspired by immunology has appeared in the recent few years. It takes inspiration from the immune system in order to develop new computational mechanisms to solve problems in a broad range of domain areas. This article presents a problem oriented approach to design an immunizing solution for job recommendation problem. We will describe the immune system metaphors that are relevant to job recommender system. Then, discuss the design issues that should be taken into account such as, the features of the problem to be modeled, the data representation, the affinity measures, and the immune process that should be tailored for the problem. Finally, the corresponding computational modelis presented.

Key words: Recommender systems, Content-based recommender system , Collaborative filtering recommender system, Hybrid based recommender system, Computational Intelligence (CI), Artificial Immune System (AIS), Clonal Selection**,** Somatic hypermutation, Affinity measures.

1. Introduction

The Job Recommender System has been emerged in e- business online services in the few recent years. While companies publishednew job positions on the online portals, job-seeker uses them to establish their profiles. For each posted job, thousands of profiles received by companies. Consequently, a huge volume of job descriptions and candidate profiles are becoming available online. The need increases for applying the recommender system technologies that can support recruiters to handle the huge online information efficiently (Färber, Weitzel, & Keim, 2003), (Yi, Allan, & Croft, 2007).

The main challenge faced the applying of recommender system technology in candidates/job matching as recognized by the literature analysis, is the large volume of low qualification of applicants that match the search criteria (Singh, Catherine, & Visweswariah, 2010). Whereas, the best fit between job and candidates depends on underlying aspects that are hard to measure. Additionally, we notice the diversity nature of the job specification that should be considered in candidates/job matching. Certain job requirements should be modeled in many forms to meet a diverse set of candidates that satisfies job's requirements. Whereas, many applicants missed the recruiting's opportunity that result from poor job requirements' determination. Since the determined features may meet set of candidates, but still there are many other applicants suitable for the job but did not match the determined criteria. We need to determine the job's requirements by a set of vectors of different features that can meet most possible appropriate applicants, and then rank applicants depending on the matching degree between the applicant and job requirements.

Many traditional recommendation techniques have been applied to job recommendation problem. Most of these techniques produced good solutions with relatively some limitations(Al-Otaibi & Ykhlef, 2012b),(Zheng, Hong, Zhang, & Yang, 2012). In order to cope with these limitations, the natural immune system shows many properties that are benefited in this area of research. We will conduct a comprehensive study and develop a recommender system algorithm that aimed to improve the job recommendation process. We treat the recommendation process as an optimization problem that has been successfully applied in many domains such as science, engineering, management, and business. Where as, different families of optimization models are used to formulate and solve decision-making problems. Metaheuristics represent a family of optimization techniques that gained a lot of popularity in the past two decades. They are among the most promising and successful techniques that offer good solutions in a reasonable time for solving hard and complex problems in science and engineering. This explains the significant growth of interest in metaheuristics domain. In recent years, many metaheuristics are inspired by natural processes such as evolutionary algorithms from biology; ants, bees' colonies, and particle swarm optimization from swarm intelligence; and simulated annealing from physics (Talbi, 2011).More recently, a novel computational intelligence system inspired by immunology has appeared, named Artificial Immune Systems (AIS). This immune system has already been applied in solving a wide range of engineering problems.

This work explores the undertaken aspects to develop an immune inspired technique for job recommendation problem. We used the observable immune components and processes as metaphors to produce AIS algorithm. This algorithm encapsulates a number of beneficial features of the natural immune system, and they are utilized towards solving job recommendation problem.

Thearticle is organized as follows:Section 2 presents the related works. Section 3 demonstrates the background of artificial immune system and their related issues. In section 4, we illustrate how tomodel the job recommendation problem in AIS metaphor and discuss the design issues that should be taken into account. Additionally, in section 5 we present the AIS algorithm that will be applied to the job recommendation problem. We conclude this work in section 6.

2. Related Works

Many researches have been conducted to discuss different issues related to the recruiting problem as well as, the applying of recommender system technologies (Al-Otaibi & Ykhlef, 2012a),((Al-Otaibi & Ykhlef, 2012b).Zheng, et al. summarized job recommendation related issues such as user profiling and similarity calculation. They conducted empirical experiments on a local online recruiting website and presented the details of specific case study(Zheng, Hong, Zhang, & Yang, 2012). In our previous work,wepresented a comprehensive survey of job recommender systemsand listed the advantages and disadvantages of technical approaches in different job recommender systems(Al-Otaibi & Ykhlef, 2012b).

First, the content-based recommendationswhichoriginally recommend items that have similar content information to the matching users.Paparrizos, et al. built an automated system to recommend jobs for applicants based on their past job histories. This system treated the recommendation problem as a supervised machine learning problem (Paparrizos, Cambazoglu, &Gionis, 2011). The PROSPECT system, which is a decision support tool presentedin(Singh, Catherine, & Visweswariah, 2010) to shortlist candidate resumes list. It mines resumes to extract features of candidate profiles such as skills, education, and experience. The information retrieval techniques used to rank applicants for a given job position. Additionally, Yu, et al.proposed a preference method based on user's interaction history and a new similarity measurement method. The recommendation process divided into two parts: job recommendation and job-seeker recommendation. For both parts, the recommendations should be the objects which are the most consistent with their preferences(Yu, Liu, & Zhang, 2011).

Second,hybrid based recommendation which used a combination of different recommendation approaches to handle the job problem. For example, a combination of two or more approaches can be used such as content-based, collaborative filtering and knowledge-based recommendation. A recommendation system initially used

to recommend objects to users such as movies or books have been applied to matching partners(Färber, Weitzel, & Keim, 2003). They used two recommendation approaches content-based filtering and collaborative filtering simultaneously.Later, this recommendation approach utilized and extended in many works.Lee & Brusilovskyintegrated the idea of recommender systemsand the adaptive hypermediato produce the proactive recommender system(Lee & Brusilovsky, 2007). Additionally, Fazel-Zarandi & Fox improved the matching process by providing an adaptive job offering and discovery environment. They combined different matchmaking strategies in a hybrid approach for matching job seekers and jobs using logic-based and similarity-based matching (Fazel-Zarandi & Fox, 2010). The fuzzy multiple criteria algorithm determined the suitable personality traits and key specialized skills through information statistics and Analytic Hierarchy Process (Chen, 2009). Moreover,Zheng, et al. developedan online system namedI HR, which groups users into different clusters and uses different recommendation approaches for different user clusters(Zheng, Hong, Zhang, & Yang, 2013).

3. Background of Artificial Immune Systems

The immune system is one of the most complicated biology systems. The knowledge about how the immune system acts is increasing with the advances in biology and molecular genetics. This knowledge becomes very interesting not only from a biological viewpoint, but also from a computational perspective. The immune system has now started to the emergence of AIS as a novel computational intelligence paradigm. It has emerged in the 1990s as a new branch in Computational Intelligence (CI). A number of AIS models were existent, and they are used in pattern recognition, elimination, optimization, computer security, fault detection, and many other applications researchers are exploring in the field of science and engineering (Dasgupta, 2006). It is also an addition to the increasingly long queue of approaches that are biologically inspired (Garrett, 2005). These approaches comprisethe established paradigms such as Genetic and Evolutionary Computation(B¨ack, Fogel, & Michalewicz, 1997); as well the Ant Colony (Dorigo, 1992),(Dorigo, 1999) and Particles Swarm ((Kennedy & Eberhart, 1995).

We realize some general features of job recommendation problem that the AIS will really bring some benefits, and thus distinguish it from other techniques. We will attempt to carefully mapping the problem features to mechanisms exhibited by the AIS, taking the problem-oriented perspective outlined and discussed in the following section. AIS can be described as metaphorical computational systems developed using ideas, theories, components, and process derived from the immune system (Castro & Timmis, 2002). Although many details of the immune mechanisms are unidentified to immunologists, however, it is well-known that the immune system is protecting our body against foreign invaders by a multilayered system. Depending on the type of the invader and the way it comes to the body, the immune system uses different response mechanisms to destroy the infected cells. It is comprised of physical barriers such as the skin and respiratory system, physiological barriers such as destructive enzymes and stomach acids and the original immune system, which has two parts, the innate and adaptive immune systems (Castro & Timmis, 2002).

The innate immune system is a stable mechanism that perceives and destroys specific invading organisms, whereas the adaptive immune system responds to anonymous foreign invader and provides a response that can persevere in the body over a long period of time. The adaptive immune system is comprised of a collection of different cells accomplishing different functions that spread over the body. The primary cells in this process are two classes of white blood cells, called T-cells and B-cells. Both classes of cells initiate in the bone marrow, although T-cells cross to the thymus to mature before they circulate the body in the blood and lymphatic vessels. First, the T-cells have three classes: T-helper cells which are responsible for the activation of B-cells, Killer T-cells which bind to foreign invaders and inset poisonous into them making their destruction, and suppressor T-cells prevent the action of other immune cells thus inhibit the allergic reactions. Second, the B-cells are responsible for the generation and secretion of antibodies using specific proteins which binding the antigen. Each B-cell can only provide one particular antibody. The antigen is located on the surface of the invading organism, and the binding of an antibody to the antigen is a signal kills the invading

cell. In general, there is more than one mechanism for the immune system (Goldsby, Kindt, & Osborne, 2002). We will focus in this research on the primary processes that utilized in most AIS models: The Clonal Selection and the Somatic Hypermutation theories(Castro & Zuben, 2001),(Castro & Timmis, 2002),(Aickelin, 2004).

3.1. The Clonal Selection Principle

TheClonal Selection Algorithm named CLONALG (Castro & Zuben, 2001)was developedto perform pattern recognition and optimization. It has exposed success on a wide range of engineering problems. Since, the Clonal Selection has a set of important features such as diversity, optimization, exploration and learning. Diversity, while the immune cells can be sparsely spread to cover a wide region of the antigenic space. Optimization fulfilled by the selection and proliferation of high affinity cells that produce a rapidly population with high affinity that supports high response to next infection. Additionally, the exploration achieved by using mutation process to reach higher affinity matches to the invading antigen. Finally, It supports the learning using repeated exposure to an antigenic stimulus can work as a method of reinforced learning. While the memory cells become more specific to the current antigen and capable to respond more rapidly to a reoccurrence (Jennifer & Simon, 2003).The Clonal Selection is an algorithm used to define the basic features of an immune response to an antigenic stimulus. It is defined the idea that only those cells that recognize the antigen are proliferate. It works on both T cells and B cells. When the body is exposed to an antigen, some of the derived B-cells respond by producing antibodies. Each cell secretes only one kind of antibody, which is relatively specific for the antigen. By binding to these receptors, with a second signal from accessory cells (T-helper cell), an antigen stimulates the B cell (lymphocytes) to proliferate and mature into antibody secreting cells, called plasma cells. Although plasma cells are the most active antibody secretors, large B cells divide rapidly and secrete antibodies at a lower rate. Although, B cells secrete antibodies, T cells do not secrete antibodies, but play a central role in the regulation of the B cell response and are preeminent in cell mediated immune. B cells are proliferated or differentiated into plasma cells and also can differentiate into long-lived B memory cells. The memory cells circulate through the blood, lymph and tissues not to build-up antibodies, but when exposed to a second antigenic stimulus start differentiating into large lymphocytes. These lymphocytes capable of producing high affinity antibody, preselected for the specific antigen that had stimulated the primary response (Castro & Zuben, 1999). Figure 1illustrates the Clonal Selection principle.

Figure 1: The Clonal Selection principle.

3.2. Somatic Hypermutation

The mutation process is the most commonly used in AIS;it means random genetic changes to the genes of the cloned cells are involved to control the antigen receptor. These changes caused proliferation and variation of high affinities antibodies. This concept was used as the basis for mutation in Clonal Selection algorithm, where the mechanism was the affinity between the antibody and the antigen(Brownlee, 2005).The mutation is applied for most applications such as: for binary strings bits are flipped, for real value strings one value is replaced at random, or for others the order of elements is swapped. Additionally, the mechanism is often

enhanced by the somatic hypermutation that noticed as a process for optimizing the binding affinity of antibodies (Aickelin, 2004).

4. Modeling Job Recommendation in AIS

The immune system is a suitable solution for job recommendation problem because of certain properties that inherent from many immune inspired algorithms. The features that are particularly relevant to recommendation problem are diversity, optimization, exploration, and learningcapability. In our case, the main task of the immune system is to search for the qualified applicants (Antigens) for a specific job position (Antibodies).

The important feature that needs justification is the diversification nature of job's requirements that should be considered in candidates/job matching, it will cause a large number of the matching process. Hence, particular job's requirements need to be modeled in many forms to meet a diverse set of candidates. For example, there are many possible terms for specialties or skills that can be considered as possible valid solutions. To illustrate the diversity nature of job problem, we can consider a certain job as set of vectors*n* composed of different *r*attributesthat can meet different candidates' characteristics. We can calculate the number of possible vectors (*NV*) in the worst case that describes the job's requirements using the r-combinations in a particular order such as:

$$NV = {}_nC_r = \frac{n!}{(n-r)!\,r!}$$

These vectors should be applied to candidates/job matching to get the best fit between job's requirements and candidates. For each candidate, we should calculate the affinity with all vectors to get the best fit between job's requirements and candidates.

Number of matching processes = number of applicants × *NV*

Generally, the diversification problem has been shown to be NP-hard. Thus, to solve large instances of the problem, we need to rely on heuristics (Drosou & Pitoura, 2010). In all metaheuristics, the contradictory criteria must be taken into account: exploration of the search space and diversification as well as exploitation of the best solutions (Talbi, 2011). The complexity of computing n! certainly takes an exponential time(Cheng, 2004). Whereas, the complexity of NP-hard problems represents the set of all decision problems that can besolved by a nondeterministic algorithm. In our case as shown, it requires an exponential time to be solved in optimality. Finally, the required search time to solve a given problem is an important issue in the selection of an optimization algorithm. Unlike traditional algorithms, metaheuristics allow to tackle large-size problem instances by delivering satisfactory solutions in a reasonable time (Talbi, 2011).

In order to apply an immune model to solve a specific problem, first we should choice the immune algorithm according to the type of problem that is being resolved. Then, determined the elements involved in the problem and how they can be modeled as objects in the immune model. To model such objects, a representation for these elements should be selected, specifically a string representation: binary, integer or real-valued vector representation or a hybrid representation. Next, suitable affinity measure should be selected to definethe matching rules (Dasgupta, 2006).The following sub-sectionsintroduce the details of the strategies used in the proposed algorithm.

4.1. Metaphorsand Parameters

This section describes themetaphorsand parametersthat will be usedthroughout the rest of this article, particularly as they used in the Clonal Selection Algorithm that applied in Job Recommender System named JRS-CSA. JRS-CSA is asimulation of immune system where the antigens attacking our body can stimulate the immune system to produce antibodies. The following lines present the metaphors and the mapping of AIS terminology toJRS-CSA.

- Body is the organization that search for candidates to be employed in an open job position.
- Antibody is the job's requirements that protect an organization (body) from nonqualified applicants.

- Antigenis any new applicant that considered as a target to be checked.

The JRS-CSA will use the following parameters:
AB represents antibodies pool.
$Ab_i$is the current antibody
*n*is the number of antibodies.
AG represents antigens pool.
$Ag_j$is the current antigen.
L is the number of parameters (length of the vector).
$D_k$is the distance between $Ag_j$and $Ab_i$for parameter k.
$Affinity_i$isthe total distance between a given $Ag_j$and Ab_i.
N is the maximum size of antibody pool.
C is the set of selected clones.
MC is the set of maturated clones.
LM is the set of long memory cells.
Threshold is the acceptance level of antigen.
Aga is the set of acceptance antigens.
d% is the percentage of removed antibodies cells.

4.2. MultiRepresentation

Along with other metaheuristics, choosing a suitable representation is very important for the algorithm's success. Antigens and antibodies are represented in the same way. For most problems the most observable representation is a string of numbers with length equal to the number of parameters, the position is the parameter and the value is the actual value of the parameter itself. In JRS-CSA, there are many parameters that should be represented to model the job's requirements as well as the applicant's resume. For example, a set of qualifications and their information, skills, languages, experience and etc. Both antigens and antibodies are represented by a vector of mix numbers (binary, integer or real). The information can be divided to six categories: personnel information, qualifications, language, skills, experience and additional information. In general, there are more than 70 possible parameters. Most of these parameters will be used in the recommendation process. Some of the parameters have multi levels of representation such as the qualification degrees and languages.To simplify the idea, possible representation of the applicant and the job vectors are:
{Applicant' id/ Job code, (PhD degree, PhD GPA, PhD specialty), (MSC degree, MSC GPA, MSC specialty), (BSC degree, BSC GPA, BSC specialty), (Diploma degree, Diploma GPA, Diploma specialty), (language, language level), type of skill, experience}.
Applicant1: {1,(0,0,0),(1,4.1,2),(1,4.02,2),(0,0,0),(1,3),1,5}
The aboveapplicant'svector means:{Applicant id, no PhD degree, MSC degree with 4.1 GPA and specialty number 2 (2 refers to Electric Engineering as determined in the input screen), BSC degree with 4.02 GPA in Electric Engineering, No diploma degree, 1 refers to English language with excellent level (3 refers to excellent level), skill no 1(1 refers to programming language skills), 5 years' experience}.
Job1:{1,(1,4.5,2),(1,4.5,2),(1,4.0,2),(0,0,0),(1,3),3,5}
The above Job's vector means: {Job code, PhD degree with 4.5 GPA in Electric Engineering, MSC degree with 4.5 GPA in Electric Engineering, BSC degree with 4.0 GPA in Electric Engineering, no diploma degree required, programming language skills,English language with excellent level, 5 years' experience}.

4.3. Multilevel Similarity Measures

The similarity or affinity is very important design choice in building an AIS algorithm, and closely coupled to the representation scheme. In JRS, the affinity is taken as the distance between a given antigen and the antibody. As illustrated in section 4.2, a string of mixed representations was used. Subsequently, the affinity is calculated using a combination of different types of similarity measures depending on the parameters' types.

Additionally, some of the parametersneeds multi-level checking. It needs pretest to determine if it is required by the recruiter for the recent job or not. For example, the certain degree that the applicant has may be it is not required for a certain job; in such case this degree should not be scored. Then, the parameters distance is taken as a Boolean match 0, no match 1 as equation (1).

$$D_K = \begin{cases} 1 & \text{if } Ag_i \neq Ab_i \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

For real attributes such as the GPA for certaindegree, the distance is calculated as a normalized distance between a given antigenand antibody as equation (2).

$$D_K = -(Ag_i - Ab_{j)}/\text{Maxvalue} \quad (2)$$

WhereMaxvalue is the maximum value for current attribute. For example, if the maximum GPA is 5 then the Maxvalue is 5.

Note: ifthe applicant GPA is more than the job's required GPA it will be decreased the distance (use *minus*).

For integer attributes such as a certain specialty or skill, the distance is also taken as equation (1)butwithout pretest.

Total affinity for an antibody with a given antigen is calculated as equation (3).

$$Affinity_{j,i} = (\sum_{k=0}^{L} D_k)/L \quad (3)$$

Where*j* represents the current antigen (Ag_j), *i* represents the current antibody (Ab_i),*k* is the current parameter and *L*is total number of parameters.Finally, the best affinity of an antigen is calculated as equation (4).

$$Affinity_{j,*} = Min(Affinity_{j,1}..Affinity_{j,n}) \quad (4)$$

Where * is a wildcard means any antibody, j is the current antigen, and $Affinity_{j,1}$ to $Affinity_{j,n}$ represent affinities of the antibodies from $antibody_1$ to $antibody_n$ for current antigen.

By applying the above affinity measures inthe examplethat introduced in section 4.2,

Applicant1: {1,(0,0,0),(1,4.1,2),(1,4.02,2),(0,0,0),(1,3),1,5}, and

Job1: {1,(1,4.5,2),(1,4.5,2),(1,4.0,2),(0,0,0),(1,3),3,5}.

We have $Affinity_{j,i}$= 0.1235.

4.4. Cloning process

Cloning can be explained as the process of producing similar populations of genetically identical individuals. In Clonal Selection, the cells with high affinity with current antigen are selected to proliferate. The proliferation rate for any immune cell is proportional to its affinity with the selective antigen: the higher the affinity, the higher the number of offspring generated and vice-versa. The number of clones created from each of the selected antibodies is proportional to their affinity using a rank based measure. This is achieved by first sorting the set of selected antibodies in increasing order by their affinity to the antigen. Then, clones are created according to the rank. Thus, the antigen selects several immune cells to proliferate. In JRS-CSA, cloning cells produce only one clone because the identical clones do not add any benefit to the processing and will give the same resultant vectors after mutation. In such case increasing the number of clones will decrease system efficiency.

4.5. Mutation Strategy

Mutation is a very common process in AIS algorithms, and in most cases it is done in absolutely random fashion by changing each bit in the solution. It is seen as a training operator which provides a small amount of random noise. This kind of unsighted mutation is not suitable for JRS because there are constraints that should be taken into account in job requirements. Additionally, due to the diversification nature of job problem that mentioned above in section 4 we should use a customized scheme. Therefore, we have applied a specific scheme of mutation to the clone cells. Where, the number of attributes changed in the clone cells is equally for all clones using predefined sets of alternatives. For example, we use the specialties and the skills alternatives

that already accepted by the recruiter for performing the mutation process. This mechanism can be seen a somatic hypermutation that noticed as a process for optimizing the binding affinity of antibodies.

5. AIS Algorithm for Job Recommender System

The proposed AIS recommender systemnamed JRS-CSA isperformedone generation once all available antigens have been exposure to the antibody cells, and all the AIS steps have been performed for each antigen. Each antibody has only one clone and the mutation process performed in the same way for all selected clones. Somatic hypermutation will be implemented using different alternatives (e.g. specialties and skills) that determined as applicable choices by the job's recruiter.The following steps illustrate the JRS-CSA.

- The initial population is generated using the job's requirements (antibodies set) and the applicants' resumes (antigens set). Both antibodies and antigens are encoded into vector space using the representation that illustrated in section 4.2. Additionally, the mutation pools (e.g. specialties and skills)areloaded using information prepared by the recruiter.
- While the stopping condition is not met (no more Antigen), the algorithm proceeds by performing a number of iterations to expose the system all antigens.
  - The system is exposed to the selected antigen, and the affinity is calculated for all antibodies against the antigen.
  - The *d%*of antibodies is selected from the entire antibody's pool that has the highest affinity with the antigen.
  - Cloning is performed; a number of clones *nc* are generated for each antibody.
  - Affinity maturation is performed (mutation) for all selected clones, such that the clones are then subjected to an affinity maturation process to enhance the matching with current antigen.
  - The resulted clones after mutation are then exposed to the same antigen, and the affinity measures are calculated.
  - The antibodies with the highest affinities in the maturated clones are then selected as candidate memory antibodies. The highest affinity with current antigen will be assignedas antigen's affinity. The antigen's affinity is compared with a certain threshold that specified by job's recruiter to determine the acceptance of an antigen.
  - If the affinity of candidate antibodies cells is higher than that of the highest stimulated antigen from the memory pool, then it replaced.
  - The antibodies cells are sorted and percentage*d%* of individuals with the lowest affinity is removed from antibody pool.
  - If the total number of antibodies cells is more than the maximum size of antibody pool (N), the antibodies cells with lowest affinities will be removed.
  - The memory antibodies pool then taken to expose next antigen.
- Finally, the set of antigens will be ranked depending on their affinities.

The following figure presents a diagrammatic representation of the steps AIS for job recommender system.

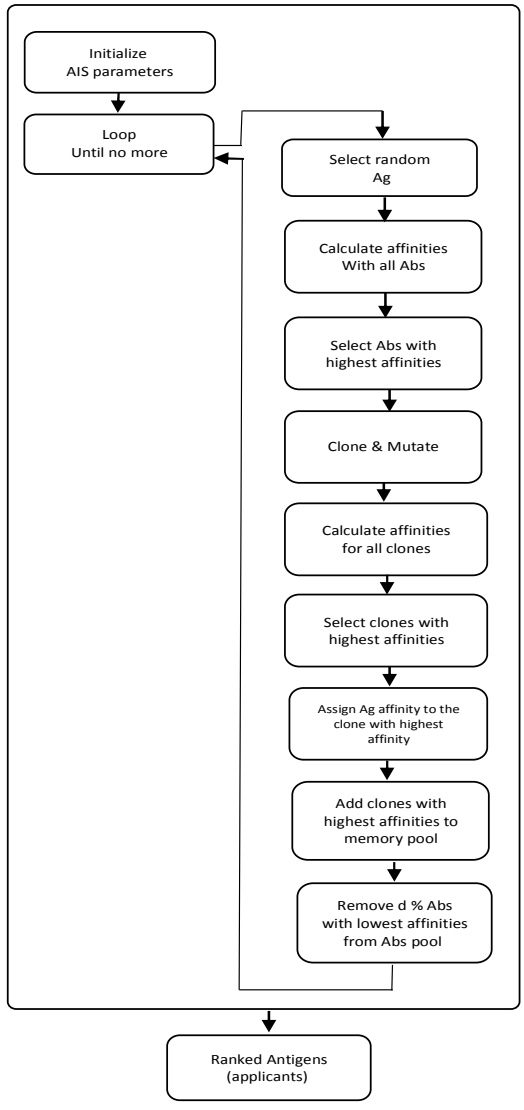

Figure 2: Diagrammatic representation ofJRS-CSA for job recommender system.

The following lines of Table 1 introduce the pseudo code for JRS-CSA and use the parameters presented in section 4.1.

Table 1: The pseudo code for JRS-CSA.

Algorithm JRS-CSA

1: **Initialize** parameters and **generate** AB, AG, and mutation pools
2: **for** j = 0 to m-1 **do**
3:**Select** (Ag[j])
4: **for** i = 0 to n-1 **do**
5:**Select** (Ab[i])
6: **CalculateAffinity**(Ag[j],Ab[i]) using equations 1,2,3
7:: **end for**
8: AB ← **Sort** (AB) according to the affinity
9: C ← **Clone (AB)**
10:**Select** the d% represents that the best antibodies
11: **for** i = 0 to nc – 1 **do**
12:MC← **Mutate**(C)
13: **end for**
14:**for** i = 0 to nmc – 1 **do**
15:**CalculateAffinity** (Ag[j],MC[i]) using equations 1,2,3
16: **end for**
17: LM ← **Add**(MC,LM)
18: **Sort** (LM) according to the affinity
19: Affinity [Agj] = **Min** (Affinity [Ab_0]…Affinity [Ab_{n-1}])
20: using equation 4
21: **if** Affinity[Agj] <= Threshold **then**
22: Aga ← **Add** (Ag[j],Aga)
23: **end if**
24: **LM** ← **Remove** *d*% of antibodies with lowest affinities from
25: the LM set
26: **for** i = 0 to nlm
27: AB ← **Add** (lm[i],AB)
28: **end for**
29: **Sort** (AB)
30: **if n > N then**
31: **for**i = 0 to n
32: **if i<= N then**
33:**AB** ← **Add**(Ab[i],AB)
34:**end if**
35: **end for**

5.1. System Implementation

From the algorithmic outlines given in previous sections, we construct a recommendersystemwritten in the c# programming language. It provides data mapping into vector space and Clonal Selection processesas well as, antigens classification algorithm. Visualization tools used to test the program result. The JRS-CSA implementation was prepared as defined in sections 45 and 5. The cloning and somatic hypermutationwas implemented as specified above, as well as the affinity calculations were performed using equations 1,2,3,4 that mentioned in section 4.3.

5.2. AnIllustrative Example

This example used a simple antibodies pool with four vectors for a specific job position. Minimal parameters were included in this example to simplify the concepts. Additionally, we use only the specialties pool for the mutation process with few numbers of alternatives. A design goal of JRS-CSA is recommended the recognized antigens that represent the qualified applicants. Figure 3 represents four antibodies for a specific job position. The variables A_1 to A_{16} refer to the parameters that mentioned in section 4.2.

Ab_i	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	A_{12}	A_{13}	A_{14}	A_{15}	A_{16}
0	1	4.5	2	1	4.5	2	1	4	2	0	0	0	1	3	3	5
1	0	0	0	1	4	2	1	4	3	1	4	3	2	3	2	7
2	0	0	0	1	4	2	1	4	2	1	4	2	1	3	3	5
3	0	0	0	0	0	0	1	4	2	1	4	3	2	3	2	10

Figure 3: Set of antibodies for a specific job position.

Figure 4 displays the specialties for the current job, such that for PhD the accepted specialty only *Computer Science* and *Telecommunication*, MSc are *Computer Science* and *Electric Engineering*and etc.

Sp-Code	Name	PhD	MSc	BSc	Dip
1	Computer Science	1	1	0	0
2	Electric Engineering	0	1	1	1
3	Telecommunication	1	0	1	1
4	Business Administration	0	0	0	0

Figure 4: The Specialties alternatives for current job.

When Ag_0 enters to the system with *d%*=50, the following list of Abs will be selected as Clone *C* cells (table 1):

Ab_i	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	A_{12}	A_{13}	A_{14}	A_{15}	A_{16}	Affinity
0	0	0	0	1	4	2	1	4	2	1	4	2	1	3	3	5	0.1235
1	1	4.5	2	1	4.5	2	1	4	2	0	0	0	1	3	3	5	0.12975

Figure 5: Set of selected Clone C.

Then, the following mutated cells *MC*will be produced.

Ab_i	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	A_{12}	A_{13}	A_{14}	A_{15}	A_{16}	Affinity
0	0	0	0	1	4	2	1	4	2	1	4	2	1	3	3	5	0.1235
1	1	4.5	2	1	4.5	2	1	4	2	0	0	0	1	3	3	5	0.12975
2	1	4.5	3	1	4.5	2	1	4	2	0	0	0	1	3	3	5	0.12975
3	0	0	0	1	4	1	1	4	2	1	4	2	1	3	3	5	0.186
4	0	0	0	1	4	2	1	4	3	1	4	2	1	3	3	5	0.186
5	1	4.5	2	1	4.5	1	1	4	2	0	0	0	1	3	3	5	0.19225
6	1	4.5	3	1	4.5	1	1	4	2	0	0	0	1	3	3	5	0.19225
7	1	4.5	2	1	4.5	2	1	4	3	0	0	0	1	3	3	5	0.19225
8	1	4.5	3	1	4.5	2	1	4	3	0	0	0	1	3	3	5	0.19225
9	0	0	0	1	4	1	1	4	3	1	4	2	1	3	3	5	0.2485
10	1	4.5	2	1	4.5	1	1	4	3	0	0	0	1	3	3	5	0.25475
11	1	4.5	3	1	4.5	1	1	4	3	0	0	0	1	3	3	5	0.25475

Figure 6: The mutated cells *MC*.

The *LM* cells appear in figure 7:

Ab_i	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	A_{12}	A_{13}	A_{14}	A_{15}	A_{16}	Affinity
0	0	0	0	1	4	2	1	4	2	1	4	2	1	3	3	5	0.1235
1	1	4.5	2	1	4.5	2	1	4	2	0	0	0	1	3	3	5	0.12975
2	1	4.5	3	1	4.5	2	1	4	2	0	0	0	1	3	3	5	0.12975
3	0	0	0	1	4	1	1	4	2	1	4	2	1	3	3	5	0.186
4	0	0	0	1	4	2	1	4	3	1	4	2	1	3	3	5	0.186
5	1	4.5	2	1	4.5	1	1	4	2	0	0	0	1	3	3	5	0.19225
6	1	4.5	3	1	4.5	1	1	4	2	0	0	0	1	3	3	5	0.19225

Figure 7: The resultant *LM* cells.

The minimum affinity will be assigned to the current antigen; such that Ag_1 = 0.1235.The produced*LM* cells compared with maximum antibodies in the system if it exceeds the maximumthen the antibodies cells with low affinities will be removed. The resultant *AB* cells that will be introduced to the next antigen appear in figure 8.

Ab_i	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	A_{12}	A_{13}	A_{14}	A_{15}	A_{16}	Affinity
0	0	0	0	1	4	2	1	4	2	1	4	2	1	3	3	5	0.1235
1	1	4.5	2	1	4.5	2	1	4	2	0	0	0	1	3	3	5	0.12975
2	1	4.5	3	1	4.5	2	1	4	2	0	0	0	1	3	3	5	0.12975
3	0	0	0	1	4	1	1	4	2	1	4	2	1	3	3	5	0.186
4	0	0	0	1	4	2	1	4	3	1	4	2	1	3	3	5	0.186
5	1	4.5	2	1	4.5	1	1	4	2	0	0	0	1	3	3	5	0.19225
6	1	4.5	3	1	4.5	1	1	4	2	0	0	0	1	3	3	5	0.19225
7	1	4.5	2	1	4.5	2	1	4	3	0	0	0	1	3	3	5	0.19225
8	1	4.5	3	1	4.5	2	1	4	3	0	0	0	1	3	3	5	0.19225
9	0	0	0	0	0	0	1	4	2	1	4	3	2	3	2	10	0.31225
10	0	0	0	1	4	2	1	4	3	1	4	3	2	3	2	7	0.3735

Figure 8: The resultant AB cells.

When*10* antigens exposed to the system, they ranked by affinities as the following set in figure 9. The *Test* column represents the acceptance result of the antigen with Threshold = 0.15, (Checked: accepted, Unchecked: rejected).

Figure 9: result of *10* antigens that selectedby the system.

6. Conclusion

The Artificial Immune System established an emergent biologically inspired computing paradigm. Whereas the principles that extracted from the immune system used to design computational algorithms to solve many engineering problems. It has been exposed to be a useful solution for complex problems such as optimization, fault detection, pattern recognition, classification and many other problems. Our proposed algorithm represents an optimization technique based on the abstractions of the Clonal Selection and somatic hypermutation theories. We used the observable immune components and processes as metaphors to produce AIS algorithm. This algorithm encapsulates a number of beneficial features of the natural immune system, and they are utilized towards solving job recommendation problem. These features include optimization, matching, diversity, and learning capability.

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REVERSES TO CURRICULUM INNOVATIONS:- SCHOOL AGRICULTURE IN KENYA: 1959-2013

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ABSTRACT

After fifty four years of secondary school agriculture providing instruction and preparing students for careers in agriculture, the question remains on the sustainability to innovations achieved to date. Observations indicate reverses to innovations rather progress as there exists a gap between the desired and the reality, the demand for quality and the relevance of what is implemented. The target population for the study included individuals and institutions with both primary and secondary information on innovative strategies on school agriculture. The study used qualitative research with historical design to purposively sample respondents from 26 secondary schools with an initial population of 104 respondents where innovative strategies on school agriculture were implemented. Self-administered interview schedules, visits to school and education offices archives for documentary sources were used to collect data. The data was synthesized and analyzed qualitatively by generating an account of curriculum innovative approaches. This involved selecting, organizing and analyzing the collected data in to topical themes and central ideas and concepts. The findings of this study shows that the perceived innovations either stagnated or were reversed leading to a knowledge and skills gap making the consumers of the curriculum less competitive in the economy of the country. This has been despite the drawing-up of a new agriculture curriculum and provision of resources and facilities. The lessons learnt in this study may help design worthwhile approaches for curriculum innovations with an increased drive for skills and knowledge in producing graduates who are destined to the world of work. The paper recommends the need to establish policy monitoring and implementation machinery to ensure that policies are interpreted and implemented as recommended.

Key words: Kenya, innovation, skills, curriculum, strategies, resources.

Introduction

Curriculum innovation refers the need with the purpose of improving and creating relevance in education. Relevancy in education leads to have large social and economic returns such as job creation, improved societal health. The world-wide desire for innovative curriculum remains the goal for educational planners. In Kenya the realization of curriculum innovations targeting school agriculture remains elusive.The drive to introduce school agriculture has been based in the belief that the strategy would improve access and at the same time respond to the needs of quality and relevance in education. The Kenya vocational agriculture programme in which resources and facilities are provided to spur innovations in the teaching of the subject dates back to 1959 (Jago & Tanner, 1999; Maxwell, 1965) when agriculture was first introduced in the Secondary School curriculum. The subject targeted rural schools, and according to World Bank (2014), ensuring access and quality must be intensified for the vast rural population who are generally excluded by poverty, ethnicity, gender and other social stigmas. Skills and knowledge acquired in school agriculture is essential in promoting increased farm production through the systematic adoption of new technology and agricultural research findings (Lewa & Ndung'u, 2012). The drive has been guided by the long established mission of agricultural

education which emphasizes the scientific study of agriculture targeting the inclusion of the farming community; to dissemination of results of research to a large category of farmers for increased and sustainable agricultural production (Acker &Grieshop, 2004).

Despite the efforts to create strategies for rural innovations transformation through school agriculture between 1959 and 1974 when the subject was launched, the policies for implementation especially on resources and facilities took a back seat as early as the 1970s as the subject effectively reverted to theoretical teaching. Whereas school agriculture in Kenya traces its origin to the US Vocational Agriculture Acts such as the National Vocational Education Act of 1963, Soretire (1968) and FAO/ILO/Ministry of Agriculture (2007) where vocational agriculture has been more these have remained hopes and wishes tucked in education policy documents gathering dust in shelves. An analysis of the foundation objectives of school agriculture EAEC(1969) shows that the innovative driven objectives would have led to technological advances in agriculture which would have narrowed the knowledge gap between the subject matter and skills required in economic undertakings.

Literature Review

Curriculum Innovations through School Agriculture

.Relevant literature reviewed in this study indicates that Kenya has had a long history of innovative ideas on school agriculture. As early as between 1928 and 1933, recommendations of the Organization of Agricultural Education for Africans and of the Directors of Education in the then three East African countries: Kenya, Uganda and Tanzania were that; agriculture be made a compulsory and examinable subject and that the practical work in the individual demonstration plots be graded equally with theory (King, 1971). It is significant to realize that whereas these recommendations were made over eighty five years ago, reality has it they were not implemented and that practical agriculture in schools has declined significantly. On the other hand, the recommendation was an innovation touching on assesement.In an effort to implement innovations the quality of examinations is paramount.(UN,2007; World Bank,2014), re-iterates that examinations are powerful tools for influencing and shaping the school curriculum. An innovative curriculum requires good assessment tools which guides policymakers in making effective decisions making tools for evaluating the cost effectiveness of innovative curriculum. The demand for a purely academic education by Kenyans has remained high going back to colonial period up to this period of time stifling innovative ideas (Sifuna, 2001) and this has stifled innovative strategies for vocational and practical oriented subjects.

There is need to understand the nature of the society in which the curricular is provided, this is essential as it will enable adjustments to the innovations with respect to agriculture and education and for sustainability. Curriculum innovations according to (Akoojee & McGraths, 2005;Koulaouzides, Vergos,Acker&Crunkilton, 2003) cannot ignore to ensure that young people are acquiring skills and knowledge that they may need to serve as facilitators to economic progress and reduction of absolute rural poverty.The immediate consumers of any curriculum innovation are the learners and the implementer who is the teacher. There is as (Stewart, Moore Flowers, 2003; Acker &Grieshop,2004) points out, the need to establish what the current and possible future learner needs in order to have successful careers after completing an education program. There is need to identify innovative approaches which may address the apparent reverses to agriculture curriculum innovations which may lead to greater investment in agriculture and a move towards sustainable rural livelihoods and by elimination of global hunger and malnutrition.

Successive reports (World Bank,2014;UN,2007 & UNSECO,2012) all emphasizes that the benefits of an innovative curriculum include provision of opportunities for life by opening-up avenues for acquiring employable skills by the youth leading to decent work and which enables them to climb out of poverty.

Sustainable innovative vocational and practical education relies heavily on what goes into it in the first place, ideas, technology, people and financial resources and these must be tied to time available. Making schooling more useful (Akoojee & McGraths, 2005; Koulaouzides, Vergos, Acker& Crunkilton, 2003; Bennel, 2007) has been a major concern for vocational and practical curriculum innovation movers and educational planner's worldwide. Experiences from Ghana show the need for appreciation to the value of transferable skills which include problem solving, effective communication of ideas, creativity and demonstration of entrepreneurial capabilities which an innovative curriculum could provide (FAO/ILO/Ministry of Agriculture, 2007).

Reverses to Curriculum Innovations

The (UN,2007; World Bank,2014; UNESCO,2012) on the other hand points out at the failure of advances to scientific and technological innovations in agriculture in addressing the needs of small scale farmer in developing countries a factor which agricultural curriculum innovators have similarly neglected. This could be due to observations which show that the position, structure and the activities of the political leadership and policy makers favours academic education which is seen as leading to greater prosperity and power. Indications from relevant literature show that agriculture in the school curriculum has been perceived as second class education unlikely to lead to modern sector employment making any innovations on the curriculum inconsequential. Analysts tend to show that there has been no meaningful approach to re-orientate the direction of education from purely academic to embrace vocational education, but reality has it that the subject has been merely added to the curriculum without change in philosophy. This is based on the fact that the establishment of school agriculture was not internalized by the rural communities as a desire to improve their lot of living standards. It has continued to reflect its introduction by foreigners in the colonial period, religious groups in which it facilitated exit of a few gifted rural youth to more prestigious clerical jobs and other white collar jobs (Griffiths, 1968; Callaway, 1971)

Approaches to School Agriculture in the 8-4-4 System of Education.

The re-introduction of school agriculture launching in 1984 of the 8-4-4 system of education was considered to be at the very heart of relevance in education (GoK, 1984). The 8-4-4 system of education approach aimed to reflect the philosophy of experiential education and a foundation of practical agriculture (Aldrich, 1988; Brunner, 1996 & Bird, 2002). This new initiative was to revamp the Kenya Vocational Agriculture programme launched between 1959 -67, and which had been expanded to 135 schools by 1984 (GoK, 1984; Maxwell,1965; Onyango, 1975). It was believed that the practical and vocational curriculum approach would ensure that the students graduating at different levels of education would have been equipped with scientific and practical skills essential for self and salary employment or higher levels of education.

Despite the noble 8-4-4 approach to practical and work oriented curriculum, reality has it that the innovative ideas remained still-born as theoretical teaching and aspirations to academic certificates at the expense on skills, attitudes and values which can enrich community development is buried. Both, Sifuna (2001) and Chrisman,(1987) rightly contends that a purely academic education in Africa is still perceived as the major determining factor for social mobility and that it is only through this type of education that an individual can achieve higher occupational enhancement, high income, higher status and higher prestige. This perception according to (Onyango,1975), can be traced to colonial era in which the peasant or the children of the poor were to remain attached to the land and with practical oriented curriculum, and that their education should fit them for that status in life.

The above is also reinforced by the deep-rooted and quiet negative attitude to vocational subjects by teachers, parents and students who continue to view practical subjects as inferior form of education and in such circumstances the provision of resources and facilities is in effect inconsequential (King & McGrath,2002). Indications from schools through occasional visits show that despite the existence of agriculture teaching

facilities, the schools have adopted the "chalk and talk" teaching strategy which in the views of (Stewart, Moore& Flowers, 2004; Onyango,1975) does not relate to ask for innovations in education.

Innovations and the Teacher

Innovative curriculum promotes creativity in teaching and must be linked to their training. Innovative teachers Dewey (1915) promote learner centered approach that develops the psychology of the educator ahead or in conjunction with the use of resources. This strategy for learning by doing and that the learners must be active participants in educational encounter. Where stagnation to innovation emerges there must be a review of the strategy Sarason (1990).The teacher must be able to engage teachable methods with the ultimate goal of assisting learners to be intrinsically motivated to educate them.

It is noteworthy to say that innovations are usually promoted teachers who are thinkers Kohn (1999) and whose desires are to address the societal ills or promote societal changes, most often through a change in the education. Successful innovations according to Sarason (1990) require teachers to look for new ideas and new ways of delivering our materials and programs. The speed at which technology and knowledge is advancing requires teachers to prepare students to adopt with change. Helping the learner to deal with change is a strategy of ensuring sustainable innovations in the curriculum. Rosco (1999) expresses the view that to ensure a sustainable innovative agricultural education proramme, there is a need to attract and keep high quality teachers. To achieve this, teachers would need the support from stakeholders to help them keep pace with changes in teaching technology, and methodology and technical knowledge in agriculture.

This paper presents an analysis of innovative approaches to school agriculture in the secondary school curriculum. The paper further sought to establish and analyze the relevancy of resources and facilities provided for teaching agriculture over the study period and their implications to curriculum innovations. Practical based learning reinforces problem solving and inquiry-based teaching and learning which breeds innovations. The literature reviewed shows that an approach where the curriculum is backed by relevant resources, the students see learning as interesting and meaningful and this can be one way of addressing the negative perception in school agriculture (King & Martin, 2002; UNESCO ,2005),get the innovations breeding further innovations and not reversals to creativity.

Theoretical Framework

This paper has investigated, examined and analyzed the approaches to the implementation of school agriculture curriculum within the context of relevancy to the societal goals and aspirations (Dewey, 1915; Haralambos & Heald, 1980). An approach to provide resources and facilities relating to the syllabuses and curricula was a response to the functionalist theory of the French sociologist Emile Durkheim (Haralambos & Heald, 1980) which sees education as the transmission of the society's norms, values and skills.

Methodology

This study adopted a largely qualitative approach of historical design. It used the systematic nature of historical studies by interviews, documentation of past records from schools, education offices and archives to research for facts relating to approaches to curriculum innovations. These were described, analyzed and interpreted with reference to their impact on curriculum innovations. The study further searched for information relating to provision of resources and facilities relevant to secondary schools with a view for creativity and innovations in teaching. The study adopted a variety of foci that historical research uses such as; issues, movements, concepts, approaches, theories and development (Smit, 2003 & Wiersma, 1995). The historical research in this study contributed in covering a broad area which led to the understanding on approaches to curriculum innovation strategies. The study, (Keppel, 1999) involved un-obtrusive methods that investigated the process and occurrences at different times and in different places. It involved data collection through interviews to the actual participants who were involved in designing the approaches

touching various aspects of curriculum innovations. The individuals interviewed for information included former and current agriculture teachers who taught and were believed to have .been key to Agriculture curriculum implementation, the current and former head teachers who in their roles sourced for the resources and facilities and who were the implementers of the curricula polices at the school level. The study further targeted the archives, actual sites where the resources were provided, libraries, diaries, government plans, newspapers and official curricula and reports relating to the resources and facilities provision and use. The study purposively sampled 26 secondary schools in which agriculture was taught over the study period, the schools represented a select category of the population with specific data requirements.

Results and Discussions

A review of the related literature identified several approaches including education commission recommendations and agreements dating back to the colonial period which had linkages to syllabuses, curricula, resources and facilities for teaching agriculture. An analysis of different reports and recommendations, visits to schools and workshops involving a wide category of Stake-Holders revealed varied approaches to reform the education by including agriculture in the school curriculum.

a) ***Secondary School Agriculture as an Innovative Curriculum Movement.***

The drive for curriculum innovation in Kenya can be traced to 1959 at Chavakali High School in the current Vihiga County-Kenya. The objective of the strategy included making rural secondary schools more responsive to the needs of society.The strategy was promoting the subject so that all people will value and understand the vital role of agriculture in the society.

.The findings of this study shows that Kenya vocational agriculture policy which covered the period between 1959 to 1971 and which included the Chavakali High School, the USAID and IDA projects, set the direction for innovative teaching of school agriculture. The Chavakali Vocational Agricultural Programme project was supported by a clear syllabus approved by the Government of Kenya, Cambridge Examinations Syndicate and the 1969 East African Examinations Council syllabus. The programme had support through defined identifiable resources, equipment and other facilities which were considered relevant for the implementation of the curriculum. The syllabus shows the content and other strategies like the project work, field visits and extra activities, which were considered essential for vocational agriculture.

In analyzing the Chavakali syllabus to facilities, equipment and resources, several observations relating to different sections of the syllabus can be arrived at. Generally the syllabus shows that it lacked specific or broad objectives for the content. In the absence of syllabus objectives, it becomes difficult for the teacher to implement the syllabus as it is not easy to pick the relevant resources, and facilities. However, the syllabus was quite detailed in content. It had adequate coverage in skills acquisition which allowed wide use of different resources, and facilities. The syllabus similarly allowed connections with various stakeholders in the agricultural industry.

This study has established that for innovations to have taken roots there was a need for community participation, in the absence of this the needs of the agricultural industry was not served. Samples of examination items from the examining bodies, the East Africa Examinations Council, and the Kenya National Examinations Council over the study period reveal that although these resources and facilities were provided, their use did constitute an area of examination. Most of the questions focused on identification of tools and theoretical questions on maintenance of workshop tools and equipment. It was illogical to provide tools of such magnitude in terms of cost, quality and specialty only for identification. Instead of testing the psychomotor skills and applications on use of the resources, the testing emphasized identification using photographs. This in deed was far from innovations

The study further shows that the type of tools, equipment and facilities supplied required trained engineers or mechanics technicians, animal husbandry and crop husbandry technicians to handle. It was a task beyond the competency of an agriculture teacher trained in the general area of agriculture. In the absence of the above, innovations is stifled as the would be user cannot handle the tool. Furthermore is not possible for an agriculture teacher to be competent in all aspects of agriculture. The mis use of the resources is evidenced by the remnants of resources and facilities found lying in waste in several schools where such facilities had been supplied either under the Chavakali project, the USAID, IDA and the Kenya Government project schools. Among the relics includes farm structures, tractors, cultivators, combine harvesters an assortment of tools and equipment like welders, microscopes, engineering surveying equipment and audio teaching resources like over-head projectors. The agriculture buildings which had been considered as a leading mark of schools teaching agriculture had been converted to other uses, such as industrial education, science laboratories, dormitories and general workshop for maintenance.

Innovations and reforms require monitoring and evaluation for continuity or modifications. The study has established that this was not the case with school agriculture. The study shows expansion to more schools without regard to financial implications. This is evidenced by the 1970-74 development plan coming immediately after the USAID and IDA in which a recommendation to construct of 75 agriculture workshops to be built in secondary schools over the plan period. This was in support for the 1969 Agriculture Principles and Practices Syllabus adopted in East Africa. Notably although the workshops were to be constructed, it became apparent that the magnitude of the funding was not sustainable.

The relationship in funding for resources and facilities which had a bearing on teaching methodology is noted with respect to reduced level of funding as compared to the vocational program between 1959 and 1969. Whereas the funding was scaled down, the syllabus remained the same in terms of objectives, content, resource needs and the teaching methodology. The 1970-74 development plans shows the initial financing level at a cost of £258,000 or Kshs. 5,160,000 for the 75 workshops recommended, the average of Kshs. 122,857 per school. In May 1974, the MOE released £14,000 (equivalent to Kshs. 280,000) at an average of Kshs. 20,000 per school to 14 schools for purchase of agriculture tools and requirement. Documentary sources and the response from the respondents in this study show that after the 1970-74 Development plans, the funding for the subject ceased and therefore the variations in resources and facilities became a reality as the funding levels declined. The provision of resources and facilities similarly ceased. When the funding ceased, the motivation for practical teaching of agriculture also diminished, and the subject turned to be theoretical and any gains made in reforming school agriculture took a downward trend.

The findings of this study shows the 8-4-4 system of education which was to more practical and problem solving curriculum shows to the contrary that it instead entrenched theoretical teaching of the subject by doing away with the requirement of land as a basic facility for teaching the subject. In the absence of land and other resources for teaching the subject, the above recommendations were inconsequential.

A visit to the 43 schools in the study provides summarized findings in Table 1 giving a clear picture of implications of resources to possibilities to innovations. Documentary data and school records show that all the ten USAID and IDA project schools in this study had been supplied with tools, equipment and facilities which when put in the hands of competent teachers, would facilitate creativity in class room work. An interview with the former and current teachers from these schools with regard to the common methods of teaching reveal that only seven out of the 43 had a practical approach to the teaching of the subject. The seven schools fall within the category schools which were not provided with resources but went out on their way to promote creativity. A related finding from the 43 schools visited was the relationship of the school farm as a teaching facility in relation to possible innovative activities as shown in Table 1.

Table 1: Category of schools visited in-relation to availability and use of agriculture workshop and facilities for innovative teaching and learning

Category of school	Number of schools visited	Schools with workshop facilities	Workshops and facilities used in agriculture	Workshops & facilities used for other purposes	Un used workshops and facilities	Schools without workshops and facilities
USAID Funded	6	6	0	6	-	0
IDA/ Kenya Government	5	5	0	4	1	0
Kenya Government Funded	12	7	1	6	-	5
Non funded	20	0	-	-	-	20
Total	**43**	**18**	**1**	**16**	**1**	**25**

Table 1 reveals most insight information. It shows that 25 or 58% of the 43 schools in the study had no workshops, but much more revealing information was that only 13 or 40% of the 32 schools which fell under the Kenya Government had workshops. From the table, it can be seen that none of the 11 schools funded by the USAID or IDA were using the workshops for teaching agriculture. Of the 18 workshops from the 43 schools visited in this study, only one is being used for teaching agriculture. It can be construed that had these few workshops been put in to effective use agricultural technology and indeed innovations and creative teaching would have instituted.

Table **2: Category of schools visited by availability and use of school farm for teaching agriculture**

Nature of farms in schools	USAID schools	IDA/WB Schools	Kenya Government Funded	Kenya Government Non Funded	Total
Schools with agriculture farms	6	5	12	19	42
Schools with Y.F.C. plots	1	1	2	6	10
Schools with demonstration plots	0	0	0	4	4
Schools with commercial agriculture farms	6	5	12	19	42
Schools with KNEC plots	6	5	12	19	42
School farms under Agriculture teacher	0	0	1	4	5
School farms under head teacher	6	5	11	15	37
Schools without school farms	-	0	0	1	1

Table 2 further shows that out of 42 schools with school farms, only 5 schools had the agriculture teachers involved in managing the school farm for teaching purposes; this reflects that 88% of the schools have school farms whose functions are outsides the agriculture teacher's use. Responses from teachers show that the school farms exist only in theory and as such the activities in the farm never show any creativity. Similarly, in all the 42 schools with school farms, it is only in 5 schools where the agriculture teachers are given roles to play in the school farms, this reflects that the school farms are under the total control of the head teachers, or it is only the head teachers who can explain the roles of school farms under their care. Further findings show that the students are not incorporated in the school farms for any purposes except the Form IV KCSE projects. None of the schools have either the demonstration plots or the Young Farmer's Club plots for practical teaching of the subject which implies absence of leadership and project learning.

Conclusions and Recommendations

The results and the findings confirm that the standards of what would have constituted an innovative school agriculture curriculum were set under the Kenya Vocational Agriculture programme between 1959 and 1974 and those adequate and relevant resources and facilities were provided for the same.

However, it can also be concluded that the teachers of agriculture failed to translate the curriculum objectives in an innovative strategy, they had the resources and facilities on would ask on the quality of their training, their visions and missions for the subject. This is a major reason for the downward trend in school agriculture.

The agriculture teachers have lost control of the school farm which could have been used to promote agricultural education for entrepreneurship a key area in innovations in agriculture. Every student must have a chance to entrepreneurial aspects of agriculture.

Innovations must be sustainable and breed further innovations short term innovative goals can withstand the test of change Self sufficiency at the school level is only a replica for subsistence farming. Most schools view agriculture in this direction. Collaboration with farmers and community development agents would see school agriculture taking lead in areas such as value chain addition. School agriculture may become irrelevant if does not respond to the societal challenges.

The agriculture teacher plays a key role in innovative and creative teaching. The methodology employed by teachers must be meaningful and enjoyable for both learners and teachers. The agriculture teachers should continue to evaluate, reconstruct, and improve the face of school agriculture as we focus to the next century. However this they will not achieve on their own but the stake holders must provide high quality instructional materials to stimulate innovations in agriculture

The contribution of agriculture teachers in reverses to innovations are more than the factors outside the classroom and the downward trend can be effectively halted by the teachers. There is a need for teachers to include wider participation of community stakeholders in agriculture to determine the agricultural education program in line with the community needs and school syllabuses. These will the teacher to determine where to put emphasis on.

The drive for excellence in examinations has overshadowed the relevance of skills, values and attitudes hence relegating the drive for reforms in which vocational and practical subjects like agriculture struggling to remain afloat. This implies that the provision of resources and facilities for school agriculture has been inconsequential. An analysis from KNEC reports of 1999 and 2000 shows, impressive results from schools on agriculture yet there are no facilities, for teaching the subject in the same schools. The performance has no relations with facilities and resources besides books, teachers and the chalk. This re-affirms the historical misconception that, the teacher is the omnipotent and the unchallenged source of knowledge through the lecture and the chalked –up notes delivered and hence the irrelevancy of resources and facilities. The drive for curriculum reforms in which agriculture is included in the school curriculum has remained a wish and the hopes and aspirations on what school agriculture continues to be elusive.

This paper recommends that hard decisions have to be made on the education and training of agriculture teachers. Many institutions have mounted agricultural education courses. An analysis on the content of their programmes calls for an urgent stakeholder's conference to determine the mission and philosophy of school agriculture in the country. This will guide those offering agricultural education courses for teachers to address the downward trend of the subject. Similarly, the Education Ministry needs to define a strategy of monitoring and implementing recommendations from different commissions and committees.

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The experience of African immigrant Professors in a predominantly White Academic environment

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Abstract

This study investigates the reasons for migrating to the U.S., classroom teaching experiences, experiences with students, other faculty members, and administrators; experiences with tenure, promotion and professional development; experiences with race and racism; experiences with the university academic culture, and coping mechanisms. This study is a phenomenological inquiry into the experiences of sub-Saharan African professors teaching in a predominantly White university in the Midwest of the U.S. The rationale for the study is to gain understanding of the experiences and challenges of sub-Saharan African professors through their narratives.

The study revealed that factors such as political instability, better career opportunities, and personal reasons underpinned their reasons to migrate to the U.S. It also revealed that sub-Saharan African faculty had to put extra time and effort into their preparation towards teaching in order to prove themselves competent.

Keywords: classroom teaching experiences, phenomenological inquiry, racism,

Background of the Study

There are differences in the organization of learning and teaching in American universities compared to the pedagogy back home in Ghana. In Ghana for instance, from primary school all the way through the university, students sit in rows facing the teacher/professor and listen while the teacher/professor deliver the lecture to students. The mode of instruction is didactic and there is little room for students to engage the teacher/professor or fellow students in the exchange of ideas. Knowledge is believed to reside with the teacher/professor who imparts this in a structured setting to students. Classroom organization and furniture is fixed at all the various levels of the formal educational system and there is hardly any variation of the sitting arrangement from primary school all the way to the university.

Unlike the current site of this study where the mode of instruction takes different forms- lectures, seminars, watching movies and class discussions, that of Ghana and most sub-Saharan African countries is by and large the lecture method. Professors in Ghana rarely engage students in class discussions. Students are sent to teaching assistants to answer questions and to help students with tutorials.

The researchers trace the differences between the U.S. educational system and that of sub-Saharan Africa to the genesis of formal education in the later. The educational systems introduced in Africa by the colonialists, mainly the British and the French were influenced to a great extent by the ideologies prevailing in the hegemonic countries at the time. In France, the ideology was egalitarianism which emphasized the notion that all men were biologically equal and that government should take steps to equalize inequalities in income, wealth, and opportunity caused by capitalism. Flowing out of this egalitarian ideology was the policy of assimilation practiced by the French in their colonies to make Frenchmen out of Africans (Clignet & Foster, 1964). The British Crown on the other hand practiced the ideology of laissez-faire which emphasized minimal governmental control of the economy. The British ideology encouraged unfettered economic exploitation of the resources of the colonies with minimal degree of political interference. In practice, the British colonialists encouraged indirect rule through the devolution of political power to local agencies while the French emphasized assimilation by introducing regulations and uniformities into the social organization of its overseas territories in order to have them conform to that of metropolitan France (Clignet & Foster, 1964).

The assimilationist policies of the French colonialists encouraged the duplication of schools in its colonies parallel to the academic system in France. Although these schools were established by the Christian mission groups, the French colonial authorities firmly controlled the educational activities of the missions and the number of schools established and the curriculum taught. Due to stringent colonial administrative control in French colonies, the number of Africans converted into Black Frenchmen was minimal. French was the medium of instruction and lingua franca in all the French colonies. The trend in the British colonies on the other hand was that the Christian Missions were largely left to establish as many schools as they could. There were no controls over curriculum and instruction and as a result there were variations in the educational standards. According to Clignet & Foster (1964), the policy of the British was that the missions at least practice the axiom of "adaptation of curricula to native life" at the primary level (p. 195). Vernacular languages were therefore used in the first years of primary education in the British colonies. At the secondary and tertiary level however, the British shifted focus from their laissez-faire policy in primary education to assimilationist practices akin to that of the French. In light of the policy of rigidly following the curriculum of metropolitan Britain at the secondary and tertiary level, Africans were allowed access to British higher institutions or to the ones modelled in the colonies on British educational traditions (Mazrui, 1994; Clignet & Foster, 1964).

Migration of sub-Saharan professionals abroad has cultural implications. Every human being is a product of the culture of its society. Culture therefore has a controlling influence over the way people live, think, speak and behave. As such everywhere one goes, one carries along a "cultural baggage". This cultural baggage serves as the primary paradigm through which the world is explained and understood. It is expected that conflict, dissonance and disorientation will occur when one goes to live and work in a different culture (Kohls, 2001). For professors from sub-Saharan Africa to leave their societies and take up teaching appointments on other continents especially in the United States, a society very different from their own, could mean that they do so at a cost to their psychosocial wellbeing. It would therefore be worth finding out how the cultures of the respective African professors have shaped their experiences.

Literature Review

Sub-Saharan African Intellectuals

This section reviews the literature on the educational culture that produced intellectuals from sub-Saharan Africa. The review captures the legacy of the colonial educational system and how successive post colonial governments have nurtured and reshaped this educational legacy to produce the African scholar. The review also provides an analysis of the forces and factors driving the phenomena of migration of professionals from the African continent. The section closes with a review of how race and racial identity is used in the United States to determine the position of the individual on the hierarchy of social class and status.

The development of higher education in sub-Saharan Africa is a post-independence phenomenon (Mamdani, 1994). Before independence, the colonialists established very few universities with the near-exclusive emphasis on technical' education designed to train personnel for the colonial administration and the small private sector. After independence, the founding fathers saw the practical usefulness of education, including higher education in effecting the 'Africanization' of the civil service and the state owned corporations. Seen as an important element in producing human capital to serve the development agenda of the newly independent states, more universities were established. Although the post-independence universities were established with the purpose of training personnel to manage the 'development' process of the newly independent African countries, their establishments were modelled on the patterns of Oxbridge and the Sorbonne (Mamdani, 1994).

Intellectuals produced in sub-Saharan Africa also known as the "educated African elite" from the strict sense of social production were a product of post colonialism. Even though educated individuals existed before the establishment of colonial educational system in Africa, these individuals were denied the agency by the colonial administration to produce or reproduce themselves (Mafeje, 1994). As a result of colonial domination of the politics, economics and educational systems of sub-Saharan African countries, indigenous African intellectuals had no option but to bow to the dominating system, and to serve it. Ideologically and culturally, the African intellectuals ended up becoming alienated from themselves and their own societies (Mazrui, 1994). Even though sub-Saharan African countries gained independence in the 1960s, their educational systems, especially their universities continue to reproduce graduates with uncritical westernized forms of thought. Ali Mazrui (1994) has this to say about African universities: One paradox of the African university is that it is a champion of academic freedom but a transmitter of intellectual dependency. The African university was born as a subsidiary of a cultural transnational corporation-the Western academic establishment. The 'lack of change' in the conception of the transplanted university caused a lot of changes in the attitudes, values and world view of its products. Since the university was so uncompromising to African cultures, its impact was more culturally alienating than it need have been. A whole generation of African graduates grew up despising their own ancestry, and scrambling to imitate others. It was not the traditional African that resembled the ape; it was more the Westernized one, fascinated by the West's cultural mirror. (p. 119).

An important source of intellectual dependency of Africans south of the Sahara on the Western Europe is their inability to produce graduates and scholars using their local languages as the medium of curriculum instruction and learning. Almost all sub-Saharan African intellectuals conduct their most sophisticated conversations in European languages-English, French or Portuguese. Their most complicated thinking is also done in European language. The linguistic dependence results in producing an intellectual and scientific dependency (Mazrui, 1994). In Japan and China for instance, they have developed their language to accommodate a wide range of intellectual and scientific discourse paving the way for the production of indigenous economists, medical doctors, engineers, physicists etc. In sub-Saharan Africa however, it is

impossible to find a medical doctor or an economist who practices his profession in his local language. In deed Black African intellectuals operate within the paradigm of linguistic neo-colonialism (Mazrui, 1994).

Migration of sub-Saharan Professors abroad

Scholars have identified a variety of push and pull factors that stimulate or generate migration and immigration. African immigration to the United States is ignored in immigration studies literature. A variety of economic, political and social factors are identified as responsible for immigration (Horowitz, 1992; Watkins-Owens, 1996; Fuchs, 1992; Logan, 1992). These factors also generate the movement of African immigrants to the United States. In dilating on push and pull factors that stimulate migration Chen and Yang assert that, "favourable conditions in receiving country, such as high salaries, high living standards, good research conditions, and career opportunities, pull professional migrants to the recipient country while unfavourable conditions in the sending country push the highly trained to leave" (1998, p. 628).

Mamdani (1994) identifies two historical events in the late 1960s and 1970s that changed the relationship between sub-Saharan African states and their universities, subsequently changing the fortunes of their professors. The first event was the growing state authoritarianism, and the second was the growing fiscal crisis of these states. Growing state authoritarianism manifested in the takeover of universities as national assets and stifling their autonomy. This turned university campuses to battle zones between governments who used brute force to squelch student agitation. By the late 1970s when budgetary crisis was beginning to stifle development efforts of many sub-Saharan states, governments shifted their rhetoric from 'development' to maintenance of 'law and order' resulting in the repression of student agitation on university campuses.

The reduction in bilateral aid and foreign investment to most sub-Saharan countries in the 1980s forced them to accept loans from international financial institutions with severe budgetary disciplinary conditions of structural adjustment programs. Part of the fiscal discipline was the demand to devalue national currencies. The devaluation programs cheapened exported raw materials and primary products and increased the quantum of local currency. Sustained devaluation however spurred inflation resulting in the erosion of the living standards of citizens including academicians. The experience of collapsing infrastructure, declining levels of services and heavier teaching loads with less to show for it forced institutions of higher learning to join other discontented salaried workers in the larger society to agitate higher living wages and better conditions of service. As the agitation on campuses grew, so also was the repressive tendency of governments resulting in the closure of many universities forcing professors to seek greener pastures abroad. It is at this juncture that the World Bank stepped onto the university scene in sub-Saharan Africa to become a key player. Its modus operandi was to offer the needed carrot of financial resources; and the stick of academic relevance and financial discipline (Mamdani, 1994; Ake, 1994).

The demise of socialism and the westernization of the Soviet empire was another major blow to the fortunes of sub-Saharan African professors forcing them to leave their motherland. The phasing out of the cold war diminished the political and strategic significance of Africa. The erosion of Africa's significance in a unipolar world also diminished the need to buy off African intelligentsia and less need to make concessions to their political postures (Ake, 1994). The diminished condition in status and income forced many African professors to consider the exit option. The exit option was the migration of more and more African academics to the West, especially to the U.S. as researchers and university professors.

Racial identity of Africans in the U.S

This section provides a review of the literature on race and how racial identity was developed in the United States and how it is used to locate the individual on the social class and status hierarchy. The section also gives an overview of how the race of the individual particularly Blacks in the United States is determined and how this determination becomes the yardstick for allocating them to their social class and measuring their capabilities. Although culturally differences exist between Blacks who are Americans as a result of slavery and Blacks who voluntarily migrated to the United States from Africa, the development of racial identity in the United States does not make this distinction. The construction of racial identity in the United States therefore has implications for sub-Saharan Africans who migrate to the United States.

Identifying people by race is a way of classifying people, usually by judging how closely their phenotype fits with the somatic norm images of what the different races "look" like (Bashi & McDaniel, 1997). In the United States, having African-like features and dark skin color places one within the lower levels of the racial hierarchy (Keith & Herring, 1991; McDaniel, 1995; Telles & Murguia, 1990). As a social construct, the creation and development of race and its ideology in North America has its roots in European enslavement of the peoples of Africa (Drake, 1990; Smedley, 1993). Embedded in the race construct is the hierarchy of racial groups. Within this hierarchy, Africans were on the bottom and Europeans on the top (Keith & Herring, 1991; McDaniel, 1995; Telles & Murguia, 1990; Bashi & McDaniel, 1997). Drake (1987) asserts that, "the system was justified by the deeply felt, and sometimes theologically sanctioned, belief that black people were born to serve white people" (p. 290). The slave was expected to be different from the master in physical appearance and the physical difference between the African and the European was therefore used as defining criteria of otherness.

Racial identification is a symbol of social status, and an important factor in the maintenance of group identification (Bashi & McDaniel, 1997). Many scholars have demonstrated the close connection between racial identification and social status (Clark & Clark, 1939, 1940; Hoetink, 1962; Powell-Hopson & Hopson, 1988). Racial identity is believed to affect all racial groups within society in the same way but with different implications. An example of how racial identification has different implications is racial identification of Caucasian Americans with "Whiteness" as a confirmation of positive self-esteem among Americans of European origin. However, for African Americans this same cultural preference is a confirmation of their negative status within the society (Bashi & McDaniel, 1997).

The development of the U.S. racial system traces its roots to immigration (Bashi & McDaniel, 1997). The early history of the United States shows that migrants from Western and Northern Europe constituted in the main the citizenry of the U.S. These were followed later by immigrants from Southern and Central Europe. These latter European immigrants were initially deemed undesirable and their "Whiteness" contested. Although immigrants do not come to America racially classified (Alba, 1990; McDaniel, 1995); they are forced to assimilate as members of different racial groups because of racial stratification (Bashi & McDaniel, 1997). While immigrants from Europe will typically be assimilated into "White" America, those from Africa would be assimilated into "Blacks".

The major forms of social assimilation in the United States are cultural, physical and spatial (Bashi & McDaniel, 1997). In each of these types of assimilation, the African American is excluded (Hacker, 1992; Massey & Denton, 1993; McDaniel, 1995). African Americans are not being assimilated culturally, residentially, or physically. They are not intermarrying as often as other groups, and residential segregation is increasing. The inability of African Americans to socially assimilate has implications for Africans from the

motherland living in America. Although differences existed and continue to exist between Africans who immigrated to America and Africans who were brought as slaves, the power of monolithic view of the 'Black race" persists (Butler, 1991; Du Bois, 1935; Horton, 1993; Bashi & McDaniel, 1997).

Challenges of Focus

The literature on faculty of higher education reveals that unlike their White counterparts, there is paucity of national empirical research on the teaching experiences of minority faculty (Antonio, 2002; McGowan, 2000; Sadao, 2003; Turner & Meyers, 2000). Beyond researching the issues of recruitment and retention as barriers to faculty diversity, the value of faculty of color (African Americans, Hispanics, American Indians and Alaska Natives, Asians and Native Hawaiians and Pacific Islanders) to higher education has not been subjected to the same volume of research and debate (Antonio, 2002). Stanley (2006) asserts that there is a conspiracy of silence surrounding the experiences of faculty of color teaching in predominantly White colleges and universities.

A major reason supporting the persistence of the conspiracy of silence is the lack of a critical mass of faculty of color in higher education who will champion the research agenda of faculty of color. Available literature on minority faculty is plagued with the tension of focus. There is the tension of whether to focus on the individual faculty with regards to what minority faculty must do to survive in the academe or whether to focus on the structure of the academe- what the academe must do to recruit and enhance the critical mass of minority faculty (Johnsrud &Atwater, 1994). Two theoretical explanations are provided for this tension of focus. One explanation is that minorities are relatively newcomers into the academe and therefore need time to internalize the academe norms and standards. Once they internalize the norms and standards of the academe, they will be able to compete on an equal footing with their White counterparts (Johnsrud & Atwater, 1994).

The researchers find this explanation re-echoing a popular cliché they have heard over and over again since they stepped foot in the U.S. The cliché states that America is a land of freedom and when you work hard you realize your dreams. The proponents of this cliché however do not take cognizance of the fact that the essence of freedom is framed by the dominant White population and culture to fit and benefit themselves and not other peoples. The framers of the U.S. constitution for instance, were all men and rich landlords. Their concept of freedom therefore was a reflection of their estate in life and not for men and women of other cultures. The researchers therefore agree with Bernal & Villalpando (2002) who asserted that the popular claims that higher education is objective, meritocratic, color-blind, race-neutral, and provides equal opportunities, salaries and rank for all clearly do not hold up when analyzing the racial segregation and gender stratification of faculty in American colleges and universities (p. 170).

A study conducted by Johnsrud & Sadao (1998) on the "otherness" of minority faculty found that ethnic and minority faculty members do understand the norms, standards, and culture of the academe. Additionally, minority faculty are willing to accommodate majority faculty. Minority faculty also bring alternative perspectives and experiences which they expect majority faculty to also accommodate. Sadly, however, the White majority faculty do not honor minority perspectives and experiences, but rather denigrate them (p. 337). Considering the research findings of Johnsrud & Sadao, the argument that faculty of color are newcomers into the academe and are not able to understand the norms and standards of the academe is therefore unfounded.

The second explanation provided for the tension of what to focus on in researching faculty of color teaching experiences in the academe is that the academe is fundamentally a Eurocentric patriarchal institution. The norms, standards, and culture of the academe is framed by dominant White males consequently, they are not

equally beneficial to minority faculty. The argument is therefore made that in order for minority faculty to succeed in the academe the causes of institutional racism must be identified and removed (Johnsrud & Sadao, 1998).

The researchers interpretation of the problem is that the racism faced by minority faculty in predominantly White colleges and universities is based more on "otherness" that is difference in skin color, and difference in visible physical structures of ethnicity/race than anything else. The reason for my assertion is based on the narrative of Karla Anhalt in Stanley (2006). In recounting her story, Karla indicated that people look at her in disbelief and are doubtful when she tells them that she is Mexican. Many question whether she should be counted as a minority faculty because by physical appearance, Karla has a fair skin, she has lost her foreign accent after staying in the U.S. for 15 years, and her name is of German origin (p. 42).

METHODOLOGY

Research Design

Methodological Approach

According to Albert Einstein the eminent scientist, as cited by Patton (2002, p. 12), "not everything that can be counted counts and not everything that counts can be counted." Einstein's wise saying sums up the purposeful difference between quantitative and qualitative research. Some research questions lend themselves to numerical answers-positivist paradigm; while others seek for detailed understanding-interpretive (also referred to as constructivist) paradigm, which focused on social constructs that were complex and always evolving, making them less amenable to precise measurement or numerical interpretation (Glesne, 1999).

This research carefully and thoroughly captured and described in detail the lived experiences of sub-Saharan African professors teaching at a predominantly White Midwest university. This study did not lend itself to numerical analysis and answers. Since the focus of this study provided a thick and rich description of the experiences of professors from sub-Saharan Africa teaching at a predominantly White university in the Midwest, the study fell within qualitative research. The rationale for collecting material on the lived experiences of the African professors was to understand from their perspectives what their experiences mean to them. It was also to give voice to their experiences which have to the best of my knowledge hitherto not been heard among the voices within the U.S. academe. According to Bogdan and Biklen, qualitative research is descriptive; the data collected take the form of words or pictures rather than numbers (2007). The appropriate qualitative methodological approach to the study was therefore phenomenology.

Phenomenology focuses on describing the meanings people give to their lived experiences (Patton, 2002; Creswell, 1998). Phenomenology studies the essence of a phenomenon i.e. what makes a 'thing' what it is. According to Manen (1990), phenomenology aims at gaining a deeper understanding of the nature or meaning of our everyday experiences. Phenomenology asks, "What was this kind of experience like?" (p. 9). The purpose of phenomenology is to describe a lived experience before the experience is conceptualized, categorized, or reflected upon. In other words, the task of phenomenological research and writing is to construct a possible interpretation of the nature of a certain human experience (Manen, 1990, p. 41).

Generally, a variety of techniques are used in collecting phenomenological data. One method is for the researcher to ask the individual whose experience is to be studied to write down his/her experience. The original written text of the person under investigation is called "protocol." The protocol becomes a data source

for the phenomenologist to work with. Interviewing is another method used to collect lived experiences. In phenomenological studies, interviewing is used to explore and gather experiential information. It is also used as a means of engaging in conversation with the interviewee with the purpose of understanding the meaning of an experience. Another method used to collect phenomenological data is close observation. This method is appropriate for collecting lived experience of children. With the method of close observation, the researcher is expected to be a participant and an observer at the same time (participant observation technique). The method also requires that the researcher constantly steps back to reflect on the meaning of the situation. In situations of close observation for lived meaning, the researcher gather data termed as anecdotes i.e. a certain kind of narrative with a point (Manen, 1990). Other sources of material for phenomenological studies include literature, poetry, novels, biographies, autobiographies, personal life histories, diaries, journals, logs, stories, and plays. According to Manen (1990) non-discursive artistic material such as painting, sculpture, music, cinematography, etc are also resources for phenomenological studies (p. 74).

This study was an attempt to enter into the academic lives of sub-Saharan African professors at a predominantly White university in the Midwest in order to document what their reality or life world experiences were. Their lived experiences make up their reality and therefore subject to their interpretation. The researchers therefore described truths from the perspective of my respondents and not facts from a positivist science perspective. These truths were shaped by my respondents' cultural and linguistic paradigms and were therefore socially constructed (Patton, 2002).

Selection of Participants

The research sample for this study was drawn from sub-Saharan African professors teaching at a predominantly White university in the Midwest. The population for this study was all the sub-Saharan African professors teaching in the selected Midwest University. There were twelve sub-Saharan African professors teaching in the selected Midwest University. Thus, all the sub-Saharan professors were chosen as part of the sampled population because the population size was small and also because the research was a case study. The study captured the experiences of tenured, tenure-track, and untenured professors to provide a holistic picture of their experiences.

Participants in this study were selected using the purposeful sampling technique. Purposeful sampling technique was used in the selection of participants in order to ensure that participants provided rich data regarding their lived experiences in the U.S. university academe. According to Patton (2002), purposeful sampling has the power to produce information-rich cases for in-depth study. Thus in this study only professors who bore the core characteristics of hailing from sub-Saharan Africa were purposefully selected. They therefore not only provided a rich source of information, but greatly enhanced the quality of data collected, and shed great light on the phenomenon being studied.

Data Sources and Collection Procedures

Data Sources

Data for this study was generated from in-depth, open-ended interviews of sub-Saharan African professors teaching at a predominantly White university in the Midwest. The interviews were complemented with observations of classroom teaching experiences of sub-Saharan faculty. The data gathering sources included in-depth open-ended interviewing, and direct observation. Glesne (2005) held that using multiple data collection methods contributed to enhancing the trustworthiness of the study. In expounding on the utility of using multiple data gathering methods Patton (2002) had this to say, "studies that use only one method were

more vulnerable to errors linked to that particular method than studies that use multiple methods in which different types of data provide cross-data validity checks" (p. 248).

In order to increase credibility of the lived experiences data gathering and management process, the researchers' audio taped all the interviews in addition to taking hand written notes. The researchers' also transcribed verbatim what my respondents said. Secondly, the researchers observed some of the classes the sub-Saharan African professors taught. The aim of attending these classes was to observe the verbal and non-verbal communication between the professors and their students. By attending the classes of my respondents, the researchers' observed a firsthand part of their teaching experiences. The researchers' believed combining the interviewing technique with participant observation in the classrooms of the professors strengthened the credibility of the data gathering process, and the trustworthiness of the outcome.

Data Collection Procedure

In-depth interviewing case study technique was utilized in the collection of the lived experiences of the sub-Saharan African professors. Interviewing technique was in sync with phenomenological data gathering. According to Patton (2002), to gather phenomenological data, one must undertake in-depth interviewing with people who have directly experienced the phenomenon of interest as opposed to second hand experience (p. 104).

Case study is an in-depth investigation of a discrete entity (which may be a single setting, subject, collection or event) on the assumption that it was possible to derive knowledge of the wider phenomenon from intensive investigation of a specific instance or case (Becker, 1970, p. 75). Case study as a qualitative methodological approach is a blanket category that applied to a number of research types, each of which has particular procedures and benefits (Patton 2002). Some of the case study methods include: observational case studies, interview case studies, organizational case studies, life history case studies, and multi-site and comparative case studies. A case study is both a process of inquiry and the end product. Some case studies were referred to by the methodological technique used in studying them with the view to emphasizing their process of study for instance, observational case study, interview case studies, and comparative case studies (Creswell, 1998). Other case studies emphasized the end product of the inquiry and were therefore referred to by the end product labels. Examples of case studies that emphasize the end product included organizational case studies and life history case studies.

Instrument

The data gathering instrument was a semi-structured interview protocol. According to Patton (2002), interviewing allows researcher to enter into respondents perspectives and find out what is in and on the mind of respondents (p. 341). The interview instrument consisted of a list of questions to guide, probe and explore the perspectives and experiences of my respondents. The interview guide ensured that limited time on the hands of respondents was well utilized and every respondent was systematically interviewed with the same questions. The interviews were conducted in a face-to-face setting and were recorded on audio tape.

Interpretation of Data

Being a qualitative research, this study was taken through the inductive process of analysis and interpretation. The process of qualitative data interpretation involved taking the raw data through the process of analysis and transforming it into findings. According to Patton (2002) transforming raw qualitative data into findings was akin to the metamorphoses that takes place in a caterpillar from its unattractive beginning into the splendor of the mature butterfly. The analytical process of the data passed through the transformative process of organizing the data, segmenting the data into meaningful units, coding, synthesizing, and looking for emergent

patterns, themes and categories. The findings which emerged after data analysis became the product for interpretation. Data interpretation refers to "developing ideas about findings and relating them to the literature and to broader concerns and concepts (Bogdan & Biklen, 2007). The interpretation process also involved explaining the importance of the findings, how it elucidated relevant theory and other scholarship, how it informed policy and future action that needed to be taken.

Sub-Saharan faculty in the U.S. academe.

Throughout the interviews, the researchers believe my respondents were aware that that the researchers were listening with rapt attention and open mind to what they were saying, and expressing. They also felt the researchers were ready to learn from what they had to say, and to seek understanding by asking respondents to elaborate on their responses. As a result, respondents went beyond superficial answers to share very deep and intimate personal experiences. Subsequent to this positive development all the interviewees went beyond the one hour allotted for the interview session. At the end of the interview sessions all of the respondents requested they be contacted if researchers had further questions to ask them or if researchers had any point in the interview that needed further clarification.

During the process of coding the data, researchers contacted some of the respondents by email to clarify some of their responses which they did also by email. The clarifications focused on whether their mentors were internal or external, and the extent to which respondents collaborated on research with their American peers. When the draft findings were completed, the quotes used for each respondent was highlighted to them for their validation. The findings were sent to them by email and their feedback was given through the email. The researchers went to respondents a second time to those who did not give feedback through the email to ensure that all respondents validated their responses used in the study.. The feedback the researchers received did not change any of the findings nor the substance of the interviews granted originally. The feedback was mainly about taking additional care to protect the identity of respondents.

FINDINGS

In analyzing the background data regarding why the researchers' respondents migrated to the United States, the following themes emerged: Attractive career opportunities; unfavorable political climate; and, personal reasons.
Data on the main research question about classroom teaching experiences yielded the following themes: preparing for classes and dealing with issues of competency; classroom interaction and pedagogy; student complaints and accent; classroom attitude and behaviors; outside classroom attitude and behaviors.

The above themes have their grounding in the interview and observation data collected. Each theme has been presented using the rich descriptions of the respondents. The presentation of each theme was followed by a discussion of the findings and its bearing on the literature.

Out of the eight sub-Saharan African professors who obtained their PhDs outside Africa only two initially returned to Africa. Only 25% of the researchers' sample went to Africa after their PhD program. 75% continued in the Western academe. Out of the five that studied in the U.S. three remained and two went initially back home to Africa. Out of the three that obtained their PhD programs in Europe, one went initially back to Africa. Three out of the ten professors interviewed were civil and public servants in their respective

home countries in Africa before embarking on their graduate programs abroad. The remaining seven professors taught in universities in their respective African home countries before pursuing PhD programs abroad.

In keeping faith with the Institutional Review Board requirement of protecting the rights and welfare of the researchers' respondents, the researchers' have used pseudonyms to protect the identity of the respondents throughout this study.

When the researchers' asked the respondents why they chose teaching in the university as a career majority of them said they did not choose teaching as a career but that the teaching profession rather chose them. The following response of Dr. Shine elaborated what most of the respondents said about the choice of university professorship as a career.

> I was chosen. I did not choose the academe. During my graduate days one of my professors felt I was gifted as a creative writer and actor and I won prizes in fiction, poetry during my graduate studies as the best student. I was very versatile and my professors felt that the only way I could be secured was to be a lecturer. I was an all round student and studied poetry, literature, and theory. At the masters level I was the best student in the faculty of arts and the vice chancellor gave me a job before I finished my masters. Before I completed the graduate program, I was made a graduate assistant and as soon as I finished I was given a full time job as a lecturer.

Dr. Sweetie also made a similar statement about how the academe chose her although she applied to jobs in the field of research and development work in Africa none of those institutions offered her a job except the academe.

> I did not choose the academe when I completed my PhD and was ready to start my professional career. The academe was one of three options. My dream was that I would get a job in either research or development or the academe after I graduated. So when I graduated, I applied to all these three sectors all over especially in Africa but the one that responded faster and in great numbers was the North American academe and that was why I ended in the U.S. academe plus, I also enjoy teaching

The above responses were generally typical of how most people determine their destinies in Africa. The guidance Dr. Shine received was typical of the belief in Africa that knowledge and wisdom resided with the elders and the younger generation was expected to be led and guided by the elders of society. Since there was a strong belief in predestination, it was not uncommon for a profession to choose you and not you choosing your profession.

Dr. Politics on the other hand was not chosen by the teaching profession. He chose the university academe among other things for the stability and security of tenure track faculty employment, the freedom in the university academe, and the flexible working hours offered by teaching in a university. Dr. Politics explained why he chose the university academe as his career path with the following words:

> I had some nasty experiences working in industry in New York and other places in the United States. I therefore decided to get a teaching position in a university. I did not want to continue working in an environment where your boss could come and tell you that he does not like you, and does not want you anymore. I want a job where I know the expectations were clear, the job descriptions were clear and you know that when you do 1, 2, 3 you will get your promotion. Apart from the job security, it was fulfilling and it gives me freedom.

The respondents generally viewed the teaching profession as their calling. As a calling, they found themselves being drawn by their passion to be educators. They also saw their call to teach being confirmed and affirmed by their former professors. Having explained that they were called to the teaching profession, I was curious to find out where my respondents were called to practice their profession. The next theme provides the window into where my respondents were called to practice their teaching profession.

Reasons for Migrating to America

According to Arthur (2000) there were four reasons why Africans migrate to the U.S. These were: educational pursuit; economic reasons; to join family; and for political reasons. The reasons given by my respondents for migrating to America could be categorized into three groups-attractive career opportunities, unfavorable political climate, and personal reasons. The literature refers to the first two factors for migration (attractive career opportunities abroad and unfavorable political climate at home) as part of the "push and pull" factors. Cheng and Yang (1998) elaborate on the "push and pull" factors by stating that, "favorable conditions in the receiving county, such as high salaries, high living standards, good research conditions, and career opportunities pull professional migrants to recipient country while unfavorable conditions in the sending country push the highly trained to leave" (p. 628).

Attractive Career Opportunities

The first category was those who came to the U.S., Canada and Europe to do their PhDs and were pulled by the attractive teaching career opportunities offered by the U.S. university academe. Prior to coming to the U.S. the media and friends painted rosy images in their minds about the unlimited possibilities that exist in America for personal development and prosperity. The response of Dr. Politics provided insight into the factors that pulled this first group of sub-Saharan scholars to the American university academe. Dr. Politics remarked:

> Basically U.S. propaganda that creates the impression that U.S. was the best place to ever live influenced my decision to live and work in America. The impression about the U.S. was created in the media such that when you were growing up you think that U.S. was the best place to ever go. There were opportunities to even go to Europe after my undergraduate program but everybody thinks that U.S. was the place to go. This was portrayed in magazines, movies etc and we used to call the U.S. heaven on earth in my university back home in Africa. So the impression was that U.S. was the greatest place to ever live. That was the only motivation.

Dr. Shine was also attracted to the United States because of the perception that there were attractive career opportunities in the U.S. Dr. Shine elaborated on this perception as follows:

> In studying geography in high school, watching films and television, and reading about the U.S., my perception about the U.S. was that it was a place where I could do things that I could not do elsewhere. For instance I had a vision to be a film maker and I could not do that in England but felt I could do that in the U.S. because I am in literature, theater, and performance. Many people say that my plays were cinematic and I felt if I had the chance in America I could cease defining myself only as a scholar earning salary and engage in filmmaking that was one major reason I was attracted to the U.S. As narrated above, some of my respondents chose the United States as the place to practice their calling because of the positive imagery painted in the media about America as an attractive destination for a career in the academe. On the other hand, some of my respondents wanted to teach in their home

countries but had to leave because of the hostile political atmosphere that posed threats to their lives and to academic freedom.

The next theme deals with the researchers' respondents who were "pushed" out of their countries.

Unfavorable Political Climate

The sub-Saharan African professors who went back to Africa to teach but were pushed out by forces beyond their control form the second category of my respondents. The reasons given by those who fall in the "push" category include military dictatorship stifling academic freedom, death threats to one's life, curtailment of fundamental freedoms of dissent and free speech, corruption in government resulting in frustration and lack of job satisfaction, and corruption in the university administration resulting in an atmosphere of compromise of one's principles. Here was the lamentation of Dr. Sheba who was forced to leave his country because the government of his country decided to close down the only university in the country which he was teaching at.

> Why I had to leave my country and come to the United States was that there was a non democratic, dictatorship in my country. Churches have been affected, mosques have been affected. There was a huge crackdown on opposition. For me, why I came to the United States was that the University I was teaching at was shut down completely. The only national university in the country was closed down by the government. As an academic what do you do? The university was still closed down. Otherwise, I would still have been in Africa.

Dr. Shine had to flee his home country for his life because his life was in danger for exercising his academic freedom in ways that spoke truth to the powers governing his country at the time. He had this story to share about why he migrated abroad.

> I had lots of problems with the government because one of my plays depicted the atrocities that the government was committing in the Niger delta over oil exploration and the government was monitoring my activities. One of my plays which were a number one hit in Nigeria dramatized everything that was happening and was still happening in the Niger delta area- the killing of the chiefs, the destruction of the environment and livelihood of the people etc.
>
> That play was written in 1987 long before Ken Saro-Wiwa was killed in 1995. It was a prophetic play that I wrote. I was being harassed in subtle ways by the Nigerian government. At that time I was doing consulting work for the British Council so they advised that I apply for one of their fellowships because they felt that if I continued to stay in Nigeria I was going to be killed. They offered me the fellowship which took me to England to do my PhD and that was how I left Nigeria.

Dr. Pius also falls within the category of those who left their country of origin and migrated to the United States due to unfavorable political climate. Dr. Pius unlike Dr. Shine and Dr. Sheba was a civil servant working with the Federal Health Ministry in his country. Although Dr. Pius loved his work, his people and country, he became very frustrated with the governmental system and had to leave for the United States. Dr. Pius had this to say about why he migrated to the United States.

> As a health officer in the Federal Ministry of Health in charge of educating citizens on the harm of substance abuse, I became interested in ensuring that the tobacco company of my country had slogans put on their packages as part of the advertisement that tobacco use was injurious to human consumption. My boss told me to go for it. I designed 5 of those slogans detailing with the effect of tobacco on health and informed the tobacco company. For this to become effective it had to go through Congress and become a law so I put everything together and we lobbied our senators and House of

> Representatives. We were able to get the bill through the House of Representatives and also the Senate although it was very tough but when the bill got to the desk of the president to be signed into law he refused to sign the bill. So the tobacco companies were not mandated to put the sign on their packages without the law and the senators were also not able to veto the action of the president. I learnt later that the president did not sign because he was a terrible smoker himself and for personal reasons he refused to sign a law that affected the health of 120 million people so I became frustrated and that was why I left and came back to the U.S.

The narratives detailing the unfavorable political climate that forced my respondents from Africa reflected what Mamdani (1994) identified as the ever growing state of authoritarianism that swept across Africa in the 1970s. Part of the manifestation of this wind of authoritarianism which swept across sub-Saharan Africa was the takeover of university campuses by the State resulting in the stifling of academic freedom and turning university campuses into battle zones between government forces and the university community. Scholars who could not work under such atmospheres of repression, insecurity and mayhem had to leave for foreign destinations.

There was yet a third group of my respondents whose reasons for migrating to the United States did not fit the lure of attractive career opportunities in the U.S. academe or leave their home countries due to threats to their lives and academic freedom. They said they migrated to the United States due to personal reasons.

Personal Reasons

My respondents who said they either came back to the U.S. or stayed in the U.S. after their PhD programs for other reasons apart from "push and pull" factors were grouped into the category of personal reasons. The personal reasons given for staying or migrating to the United States included marriage to an American spouse, having children who liked the American educational environment, and not finding a job elsewhere after completing PhD program.

Dr. Union married an American when he was pursuing his PhD program here in the United States. Dr. Union felt it was more prudent to live and nurture his academic aspirations and marriage within the culture of his spouse which he Dr. Union was familiar with rather than take his wife back home in Africa-a foreign land and culture which was unfamiliar to her. Dr. Union stated his reasons for choosing to stay in the U.S. as follows:

> By the time I finished my PhD program I had gotten married and my wife was a U.S. citizen so the decision to move back to my country or stay here became a problem. I do not know whether I would have gone back to my country if I were not married. One of the things that anyone wants to do was that you want to find out whether you can practice what you have learnt. So I would have taken advantage of practical attachment here in the U.S. for at least a year before going home if I were not married. But since I was married going back to my country became an issue. We did not have children at that time so I guess my motivation to stay in the U.S. was more about proving myself and staying because I was newly married to a U.S. citizen.

Dr. Bishop was a professor in one of the universities in his country before coming to the U.S. for his graduate program. After completing his PhD he went back to his teaching appointment in his home country. After teaching for seventeen years, Dr. Bishop relocated to the United States and has been a visiting professor for the past five years. In narrating his reasons for migrating to the United States Dr. Bishop has this to say,

> Even though it was a good option for my children to come and study in the U.S., I would not want my children to be in the U.S. without following up to see what was going on with them. That was the personal reason. When my son gained admission to a university in the U.S., I felt that I should be in the

> U.S. to follow up and ensure that he was doing ok so for the past five years I have been living in the U.S. to be able to know what my children were doing and their progress in terms of their education.

Dr. Renown and Dr. Grace studied outside the U.S.A for their PhDs. While Dr. Renown had his PhD from South Africa, Dr. Grace had his from Europe. They were invited initially to the U.S. as visiting professors. When they came, they realized that their children liked the environment where the university was located and they discovered that the environment was safe and conducive to the upbringing of their children so they decided to take permanent appointment in the university which happened to be predominantly White. The narrative of Dr. Renown reflects this personal reason for migrating to the U.S.

> What brought me to the U.S. was to come and teach as a visiting professor just for one academic year. I agreed to come and I came with my kids and after the one year, my kids liked the place so much and I observed that it was a good place for the kids so I decided to stay here and teach fulltime. The main reason therefore was because the local environment not America was a very good place for my children to grow and go to school.

Dr. Grace who had his PhD in Europe and came to the U.S. immediately after completing his doctoral program intimates that he would have gone back to his home country if his family did not moved to the U.S. with him. According to him it was difficult relocating from one country to the other when children were involved. Dr. Grace explained his predicament as follows;

> Left to me alone I would have gone home long ago but based on the pressing domestic issues I have to hang on. Other attractions were secondary issues for hanging on. Where there was family involved in your movement it becomes very difficult the more you stay in one place for long. When children were involved it becomes difficult to move.

The falling standards of education especially higher education across sub-Saharan Africa since the 1980s when most African countries initiated structural adjustment programs to salvage their tattered economies forced many well meaning Africans who could afford foreign education to send their children abroad for better educational opportunities. As explained by Nkinyangi (1991) the downward slide of the economy since the 1980s in sub-Saharan Africa had deteriorating effect on educational facilities, such as classrooms, educational equipment, availability of books and teaching materials. The downward spiral of the economy of sub-Saharan African region also precipitated the drastic fall in the morale of teachers, the quality of education and educational standards. The stories of my respondents who migrated to the U.S. for personal reasons especially the need to see their children acquire quality education echoes the fallen standards of education in sub-Saharan Africa asserted by Nkinyangi (1991).

The story of Dr. Sweetie stands out among the others regarding reasons for migrating to and teaching in the U.S. academe. According to Dr. Sweetie, she initially wanted to do her PhD in her home country because of the blatant racism she encountered in Europe when she was pursuing her master's degree. Over the course of time, she had to change her mind because the research institute she worked for in her home country looked favorably on American PhDs and actually hired American PhD holders than those from any other country. After finally deciding to come to the U.S. to obtain her PhD, she planned that she would go back to work in Africa as soon as she completed her program. Unfortunately for Dr. Sweetie she could not get a job either in research, teaching, or development work in Africa when she completed her PhD program. And since she could not afford to wait hoping for a job opportunity to open up for her in Africa or her home country, she had to take up a teaching appointment in the U.S. Dr. Sweetie remarked:

> I actually applied to several jobs in the field of research, development, and the academe in Africa but I did not get those jobs. In the end I had interviews from several universities here in North America to

> teach. My former university was the first American job I applied for and they employed me. I felt I did not have the luxury to go back home and wait for a year or more expecting to get a job. I have younger siblings that I was putting through school who needed my help and I could not afford to wait for a job. My family would have thought that I was mad.

The reasons why my respondents came to the United States were categorized into three groups. Some of my respondents migrated to the U.S. because of the attractive career opportunities; others have relocated to the U.S. because of the unfavorable political climate in their countries; and the rest said they came to the United States for personal reasons. The first two reasons given by my respondents for migrating to the United States: favorable academic career opportunities in the U.S.; and unfavorable political climate in home country are captured in the literature as "pull and push" factors (Cheng & Yang, 1998). Arthur (2000) captures the third reason: personal reasons as one of the four reasons why Africans migrate to the United States.

The next theme that emerged was classroom teaching experiences of my respondents. Below were the narratives that elaborated their experiences in a predominantly White classroom.

Classroom Teaching Experiences of sub-Saharan African Professors

The main research question was addressed in this section. The research question focused attention on the classroom teaching experiences and relationship between sub-Saharan African professors and their predominantly White students. From the narratives of the respondents their classroom teaching experience starts from the preparation of their lesson notes which was most often done several weeks before the quarter commences to the first meeting with students at the beginning of the quarter, the actual delivery of lectures, grading of papers and student advising. The major themes that emerged included challenges to preparation towards teaching and dealing with issues of competency, classroom interaction and pedagogy, student complaints about accent, and attitudes and behaviors of students inside and outside the classroom.

Preparing for Classes and Dealing with issues of Competency

Most of the respondents remarked that they had to put in seven to ten times effort into their preparation towards teaching compared to their White colleagues. This extra effort was to ensure that the perception that African professors did not know enough to teach White students was not in any way confirmed. In responding to why the need to put in so much extra effort into preparing syllabi and lesson notes my respondents said that students entered the classroom under the perception that African professors were not scholarly enough and competent enough to teach White students. Dr. Shine succinctly addressed this negative perception about African professors as follows:

> I have written more courses that anybody else in the world. I do not know any other person who has written many new courses like I have done on this planet. The curriculum here in the U.S. was a White curriculum and each course I teach has to be new and different. You have to validate it and you have to make it appealing and exciting and cover new material and if you were not well read and show that you know more than they know you will be eclipsed. You have to be 7 times more intelligent than those you were working with to survive here if not you will be wiped out.

In commenting on White students' perception that African professors do not have the requisite scholarship and competency to teach White students, Dr. Pius narrated how on one occasion some White students insulted him by saying in his face, "who brought this African boy to teach us." Dr Pius went on to say that,

> The challenge was that you have to work hard-seven to ten times more than your White colleagues to show that you were competent enough to do the job. The environment does not favor minorities and you have to work hard to prove that you were competent to the task.

Dr. Union provided a contrasting overview between how professors in his home country prepare towards teaching and how as an African professor in the United States he prepared himself for each quarter.

> Preparation towards teaching starts before the quarter begins. It starts with the preparation of the syllabus. Here in the U.S. you know 1 year in advance what you were going to teach during any given quarter. Whether it was a new course or an old one you still have to prepare. In science the courses do not change because biology was biology but in the social sciences and the arts new books were being written and you have to keep moving abreast with new developments. You can decide to stick with your old textbooks but if you do that you were cheating your students and yourself because you will not have up to date information. One thing I realize back home was that our professors use the same lecture notes over and over again throughout the years. I do not think that was a good thing. Usually 2 weeks before the quarter begins you start the preparation with your course outline and readings and you post it out there. At the beginning of the quarter you start with introduction of the course syllabus, the requirements, expectation etc.

The narratives of the respondents show that they pay careful and extra attention in their preparation towards teaching. The pressure to invalidate the perception that African professors were not scholarly enough to teach White students puts a lot of stress on my respondents. The psychological pressure to perform in class and to invalidate the stereotype that African professors have inferior scholarship confirms the literature that faculty of color were subject to higher levels of job-related stress than their White counterparts (Smith & Witt, 1993).

Classroom Interaction and Pedagogy

In exception of Dr. Renown a full professor who teaches two classes during the entire academic year, the rest of the professors teach a minimum of two classes every quarter. Dr. Renown teaches only two classes because he divides his time between teaching in America and working in a theater company in South Africa. The courses taught by the African professors were both at the undergraduate and graduate levels. With the exception of Dr. Bishop and Dr. Sweetie who teaches some undergraduate classes with as many as 120 students the others teach classes ranging between fifty to ten students. The undergraduate classes and classes where undergraduate and graduate students were mixed were always bigger than the graduate classes. The professors who teach large undergraduate classes indicated that their departments provide them with graduate assistants to help them with their teaching duties.

The larger classes were taught in theater rooms where the furniture was fixed to the floor and does not allow for rearrangements. Dr. Bishop who taught in those theaters said he used the lecture method as the basic medium of teaching while students were expected to take notes. Instructional technology such as overhead projector was used to enhance the communication. Respondents said they used documentary films often to augment their lectures and to sustain the interest of students in the subject matter. This was what Dr. Politics said in relation to the use of visuals: The comments students make about my classes were mostly positive ones. They tell me they enjoy my classes especially with the video and pictures that I use to teach.

In the smaller classes which often were the graduate classes, respondents said they applied the seminar method of pedagogy. Those classes were largely discursive and in-depth analysis of required readings. The duties of the professor in those classes were to provide discussion points and general guidance based on the course

objectives and readings for that session. In all the classes observed it was noticed that where the class size was small and where the furniture was not fixed to the floor, the professors chose to have the furniture arranged in a horse shoe or oblong form to allow for face to face interaction among the students and the professor.

When the researchers' were conducting observation of Dr. Grace's classes it was noticed that Dr. Grace encouraged students to bring food during some class sections to be shared as a community of students. According to Dr. Grace the idea behind having potluck during classes was to foster among other things a learning community characterized by sharing and interaction. It was observed at first hand the sharing and interaction taking place. For example, during the time of sharing the food and eating which was always at the beginning of class, the students and Dr. Grace discussed current news related to the topic for the day. This informal discussion created a synergy and a blending of the students and the professor into one unit. There were a total of eighteen students in this class. Fourteen were White Americans; three were from Africa, and one from the Middle East. It was observed that some of the students who sat in the class initially without showing any emotions or talking to their colleagues gradually warmed-up and joined the rest of the class in the discussions.

All the respondents remarked that although they teach the dominant White epistemology, they blend this with their African communal pedagogy. Dr. Sheba shed light on the blend of White epistemology with African pedagogy as follows:

> My African culture and personality influences the way I teach. I do not think there should be any kind of hierarchy anyway. I do not believe that I know everything and my students should be taught everything. For me it works both ways. It was a give and take.
>
> There was a sharing and the communal aspect of teaching and learning was important to me and it was African. What I do with my African culture in my pedagogy was to bring my African examples into teaching while I ask students to also share examples from their culture.

Dr. Shine explained that he goes beyond just teaching White epistemology. He goes to his classes with an agenda to destroy the notion of White supremacist epistemology by bringing examples from other cultures to establish his point.

> The paradigm that European and Western epistemology was superior was what I have been destroying in my classes so when I come at it I come with a certain passion and the students can see that this professor has a certain agenda and they were excited about my courses.

In explaining how he goes beyond the chalk and the talk to opens up the classroom space for interaction and introduce African culture, Dr. Shine had this to say:

> When I am teaching, I tell students what exists in their own culture, I celebrate it and I also tell them what exists in other cultures that they do not know. I tell them that these things were missing from their own curriculum and that their curriculum only focuses on their nation and forget about the world around them so when I start this way and start talking about African culture, Caribbean culture etc then I sing, and I dance and I let them watch videos then they get into it. I also get the students to sing the songs and do the dances.

The interaction of respondents with their students in the classroom was geared towards creating an ambiance of community where there was sharing and caring. The classroom pedagogy of respondents depicted democratic pedagogy where there was give and take on the one hand between faculty and students and on the

other hand among students. The classroom interaction and pedagogy reflected the co-investigation and co-construction of knowledge (Dewey, 1944).

Student Complaints about Accent

Some of the respondents reported that students complained about their accent as African professors. According to Ochukpue (2004), where immigrants combine African sounding names with pronunciations and inflections of British-flavored accent, they evoke or reinforce discriminatory treatment. Dr. Politics disclosed that some students wrote on their student evaluations requesting that he be fired for having an accent.

The students wrote that they do not understand why the university should employ a professor like me with an accent and that I should be fired for having an accent. Due to the complaint about having a foreign accent Dr. Politics said he normally told students at the beginning of every quarter that they should tell him whenever they did not comprehend his words. He said students rarely told him that they did not understand his accent. Whenever he was teaching he watched with keen eyes the nonverbal cues of his students to ensure that they understood every word he used. Whenever he was not sure students understood his accent, he wrote the word he used on the board. Dr. Politics said that having had his education from primary school to the undergraduate level in Africa, he was aware that some of his pronunciations differed markedly from American pronunciations. When Dr. Politics class was observed, it was noticed at one point that a White male student turned to his colleague and wrote on a sheet of paper a word the professor used and started laughing. It was observed that the student mimic the professor's pronunciation several times to the hearing of his colleague sitting on the same desk.

Dr. Sweetie remarked that before she started teaching in her former university in the U.S. she had to be trained as a foreign faculty in how to teach American students. During the orientation she was told that she had to tell students at the beginning of every new class that she had an accent and that students had to pay extra attention to her. Dr. Sweetie said she observed later that this orientation was not right because anytime she told the students that she had an accent, negative comments about her having an accent appeared in the students' evaluations. However when she decided not to state upfront that she had an accent, students did not complain about her having an accent although once in a while one or two students would comment on her accent in their evaluations.

Dr. Pius also highlighted the complaint of students about him and other African professors for having an accent. He said instead of feeling bad about the complaint he normally used the opportunity to educate students on diversity, the multicultural nature of America, and challenge them to embrace the differences of others. Dr. Pius had this to say:

> Some of the students in class comment on my accent but this is not a big deal because I usually tell them that they were lazy in learning about other cultures and peoples. If they were not lazy they will make the attempt to understand my assent because I also make the effort to understand them because they also have an accent. If I can understand them and they cannot understand me then they were telling me that I am more superior to them or that they were simply lazy to learn. They also have an assent so if I can understand them then they must also try to understand me.

The above narratives of respondents show that they experienced complaints from students about their accent. The complaints sometimes found their way into student evaluations. The English spoken by the respondents was flavored with British and African accent thus the difficulty of some of the students to comprehend their accent.

The next sub-theme would highlight the general attitude and behavior of students in the classrooms of my respondents.

Classroom Attitude and Behaviors

The respondents said their classroom interaction with their students were generally cordial, interactive and enjoyable. According to them their classroom interactions were in the main reciprocally respectful. A typical description of the interaction between African faculty and students was recounted by Dr. Shine. He remarked:

> I can tell you that I have a cordial relationship with my students. For instance a White student sent me an email yesterday that he was very bored and that we should go out together for a drink. I taught this student only one course. Then we met and talked about a play I am writing to take to Paris and he was excited about this. The very bright students want to be around me always. They become very close and very good friends. It happens consistently. Those cordial atmospheres were however disrupted at other times by latent racist behaviors when students want to get away with their academic failures and weaknesses.

Dr. Sheba explained how he used to be bothered about covert racism from students when he started teaching but had to grow out of this persistent and worrisome issue. According to Dr. Sheba,

> The resistance of students was very subtle. You can tell their resistance when they start complaining about their grading, when they complain that instructions were not clear enough, when they get aggressive in their emails to you about specifications of the grading system. Oh yeah, the racist encounters were almost weekly. In the beginning, I kept questioning myself why this aggressiveness but now that I know that these aggressive behaviors from the students were racist behaviors I have adjusted myself to them. So now when they send me aggressive emails, I respond and say ok you can come to my office for us to sort the issue out. So now I have developed strategies of dealing with it. The first year I did not know what was happening. I do not want to create the impression that there was no racism, in fact there was a great deal of racism from students but it was very difficult to identify it and fight it because it was covert.

Dr. Politics narrated a story about how a White student insulted him in class when he was advising the class about the number of hours students should spend on each subject areas in order to make good grades. According to Dr. Politics, the student blurted out and said what he the professor was saying was "crap" This open attack infuriated the other students and they reprimanded the student but he was adamant stating that since he came to the university as a student he was never told by any professor to commit so much time to his studies as being advised. Here is Dr. Politics narrative:.

> I had an instance where the same student emailed me and said, "Dr Politics I have some friends coming to visit me and we were hitting the bars to go and drink so if I do not come to lectures tomorrow know that I was drunk." Although this student would not study and do his assignments he had the audacity to email me to tell me that he was going to get drank with his out of town friends. In advising them in class, I told them that if you were taking a 4 credit course this was the amount of time you needed to spend on the course and he told me that all that I was telling them was crap. One student even said to him you were so rude. He went on to say that since he came to the university he has not been studying so why should I ask them to put in so many hours into my course. I asked him whether he was doing well in the other classes and he said yes. I gave them an exam and he failed. And he told me that I was giving them too much reading to do.

Dr. Politics believed that the reaction of the other students showed that this student was racist and that he would have reacted differently to a White professor than the way he reacted towards him. According to Dr. Politics another White student came to him privately and demanded that he failed the racist student but he declined. Dr. Politics also revealed that:

> The student who considered my advising as crap together with a few other absentee students who were failing class exams reported me to the dean that they did not like my teaching and that I should be fired. The dean told the students to go back and follow the proper channels of communication by reporting first to the school director. They did and the school director also told them to come to me first to address their grievances before coming to him. The student never confronted me and that ended the matter.

The negative behavior of students towards Dr. Sheba and Dr. Politics confirmed the assertion of McGowan (2000) that White students challenge the authority and the coursework given to them by faculty of color in the classroom in predominantly White colleges and universities. The stories of respondents revealed a tension between having an overall cordial and respectful relationship with students in the classroom on the one hand and having covert racist attacks on the other. Attitude and behaviors of students towards minority faculty in predominantly White educational institutions was an important recurring theme in the literature (Stanley et al. 2003; McGowan, 2000). In their study of 15 African-American faculty across a variety of ranks Stanley et al. (2003) found that the majority of participants enjoyed teaching, describing their teaching style as "interactive" (p. 158). On the other hand, many of the participants reported instances where White students directly challenged their authority in the classroom.

Outside Classroom Attitude and Behaviors

The respondents described their experiences with student attitude outside the classroom as very interactive and friendly. They painted a picture of being constantly sought after for advising and help. Dr. Pius has this to share about his experiences with students outside of the classroom.

> All my students (over 400) know me very well because although I am the school director l make time and listen to all of them. I teach two classes every quarter and I advise 97 of those students personally, so I have their folders with me here. So they come to me and talk to me about various problems they encounter and as part of my responsibility I have to counsel them and help solve their problems. I am very close to my students so they respect me because I go out of my way to ensure that their concerns were taken care off.

Respondents used the African concept of community to explain their relationship with their students both in and outside of the classroom. According to the African professors the concept of community was all embracing and transcends boundaries of formal and informal structures, it provided a caring and nurturing environment both within and outside of formal structures. Here was how Dr. Grace explained his relationship with his students.

> My concept of pedagogy was relational. It was about training the head and the heart. It was about creating learning communities. That was why for instance, if we have classes that were very long which go beyond dinner time, we bring food and eat. I relate to them as a brother in the sense that I have an open door policy towards my students. I am available to them anytime they come to ask me for assistance. For instance if I am working on a project in my office and a student comes in to ask for my assistance I put aside what I am doing and help the person.

Overall, respondents experienced a feeling of camaraderie with students outside the classroom. While the literature (Stanley et al. 2003; McGowan, 2000) indicate that faculty of color experience negative behaviors and attitudes from students both in and outside the classroom, the cordial and respectful outside the classroom experiences of my respondents did not confirm the assertion.

SUMMARY, DISCUSSION & RECOMMENDATIONS

Summary of Findings

This study used interview and observation techniques to capture the experiences of ten sub-Saharan African professors teaching at a predominantly White American university in the Midwest. The overarching research question that guided the study was:

What were the lived experiences of sub-Saharan African professors teaching at a predominantly White university in the Midwest of United States of America? The interviews and observations were based on five specific research questions which were: reasons why sub-Saharan African professors left Africa to live in the United States and teach in the U.S. academe; what were the classroom teaching experiences and relationship of sub-Saharan African professors with their students; what was the nature of relationship of sub-Saharan African professors with their colleagues and mentors; what were the experiences of sub-Saharan African professors with tenure, promotion, and professional development; and what the experiences of sub-Saharan African professors with the academic culture U.S. academe were.

The findings of the study yielded very fascinating perspectives on the experiences of sub-Saharan African professors teaching at a predominantly White American university in the Midwest. Although the findings do not represent the experiences of all sub-Saharan African professors teaching at predominantly White American universities in the Midwest some of the themes and findings that emerged from the study were consistent with the themes in the literature that exist on minority faculty in the U.S. university academe. As mentioned earlier, the study yielded very rich descriptive data full of depth and breadth. The findings of the study therefore represented only the prominent themes that emerged in response to the research questions.

Concluding Discussions

This concluding section presents a reflection on the themes that were gleaned from the interviews and observations of research participants. The themes that emerged were attractive career opportunities; unfavorable political climate at home; personal reasons; preparing for classes and dealing with issues of competency; classroom interaction and pedagogy; student complaints about accent; classroom attitudes and behaviors; outside classroom attitude and behaviors.

Recommendations for Further Research

The study of the experiences of sub-Saharan African professors teaching in a predominantly White American university academe was a groundbreaking research. The subject matter has previously not been researched. As a forerunner study, this research paves the way for further investigation of some of the findings and related issues. The following are recommended for further study:

• This study utilized qualitative methodological approach to understand the experiences of ten sub-Saharan African professors teaching in a predominantly White American university in the Midwest. Further research of the same population using a larger sample from across the United States may yield results that can be

generalized to the experiences of sub-Saharan African professors teaching in predominantly White colleges and universities across the U.S.

• Although sub-Saharan Africa represents the Black race as opposed to the Arabs who occupy the northern portion of Africa, the peoples of sub-Saharan Africa were of varied ethnicities and therefore bring with them their unique cultural values, beliefs, and norms into the United States and the U.S. university academe. It would therefore be worthwhile to conduct a comparative study of the experiences of these different ethnicities from sub-Saharan Africa teaching in predominantly White American colleges and universities.

• Given that there were also predominantly Black Colleges and Universities in America popularly known as Historically Black Colleges and Universities (HBCU.S.), a comparative study of the experiences of sub-Saharan African professors teaching in both predominantly Black and White colleges and universities would be highly recommended.

• There is the need for further comparative research into the experiences of sub-Saharan African professors with their African American counterparts and other Black professors who come from other parts of the world to teach in the U.S.

• Future research into the experiences of sub-Saharan African professors teaching in a predominantly White American university in the Midwest by a researcher other than a native African like me would be recommended. This may remove any emic biases that my identification with the research subjects may have introduced into the study.

Conclusion

Sub-Saharan African countries continue to suffer from massive emigration of their highly skilled and educated citizens to Western Europe and the United States due to the worsening socioeconomic and political conditions on the continent. While many governments and the media accuse those who leave for greener pastures abroad as being unpatriotic and selfish (Njubi, 2002), very little research was done to identify ways and means to reverse the "brain drain" issue. Beyond categorizing the factors that engender brain drain in sub-Saharan Africa into "push and pull" factors African governments and civil society institutions interested in the development of the continent must among other things listen to the stories of those living abroad and seek ways to correct the conditions that forced them out of their countries or devise systems where their expertise could be tapped wherever they now reside.

A major approach that African countries could use to draw on the expertise of their sons and daughters living abroad was to invest in the ongoing technological advances being made in information and communication technology to transmit knowledge and technology from the developed north to sub-Saharan Africa. The internet and other modern telecommunication real time interactive tools such as cell phones and iPod could be used to engage African professors living abroad in distance education. The forces of globalization- the heightened technology of information, communication and travel shows no signs of ever receding. The trend was that it will grow in intensity further shrinking the world into a small village. Sub-Saharan African countries cannot therefore afford to continue behaving like the proverbial ostrich that contended that she was hiding from everybody by sinking her head in the sand while her whole body was on top of the sand. Every effort must be made to reap some of the benefits of globalization. By investing in instructional technology that anchors on long distance education, and by engaging sub-Saharan African professors abroad to teach in Africa through long distance education programs, the challenge of sub-Saharan African professors living on the margins of Western and American academic cultures would not only become minimized but would be turned into a strength and a source of great benefit to the educational systems of Africa.

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Water use Efficiency and Yield Response to Nitrogen Fertilizer in Common Bean (*phaseolus vulgaris l.*) Under Semi-arid Environment, Kenya.

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ABSTRACT

Common bean (Phaseolus vulgaris L.) is an important food crop in Kenya but its productivity in the semi-arid areas is limited by low soil fertility. Although beans obtain nitrogen derived from atmospheric fixation, they still require external supply of nitrogen at the early stage of establishment for maximum production. Assessment of three bean varieties (GLP 585, GLP 1004 and Pinto) was carried out at Longonot for two years between 2003 and 2004 to evaluate the crop yield and water use efficiency in response to nitrogen fertilizer application. The experimental design was a randomized complete block laid out as split plot and replicated three times. Phosphorus was applied as basal fertilizer in form of triple superphosphate at planting at the rate of 18 kg P/ha. Nitrogen was applied in form of Urea at the rate of 0 and 18 kg N/ha and was applied in two equal splits at 20 and 40 days after crop emergence. Fertilizer application was main plots while bean varieties were sub-plots. There was no significant difference in bean yield amongst the varieties, but there was significant difference in yield between seasons. There was no significant yield response to nitrogen fertilizer in all the seasons due to inadequate rainfall that was poorly distributed. The bean crop was harvested in three out of four seasons. In the season with the lowest rainfall of 189 mm, there was harvest of beans because the rainfall was well distributed within the growing season.

Key words: Bean yield, nitrogen fertilizer, semi-arid, Kenya

INTRODUCTION

One of the greatest challenges in Kenya is to produce enough food to feed the increasing population, which has been growing at 2.5 % per annum (Shiluli et al., 203). The population pressure in the limited high rainfall areas has led to migration of people to the arid and semi-arid lands (ASALs) in search for land to settle and produce food. When people migrate to the ASALs, crop cultivation is a priority in order to meet the food requirements for the family. Beans are the most commonly grown food crops by majority of people in Kenya. The common bean (*Phaseolusvulgaris L.*) is the leading legume in both production and consumption in Kenya (Martis, 1989). The annual production capacity is approximately 42,000 tons. The average yields range between 500 to 800 kg/ha (Muigai and Ndegwa, 1991), which is far below the potential production of 2 t/ha

(Thiong'o*et al.,* 2002; Macharia*et al.,* 2001). Beans require less water than maize and therefore suitable in spreading the risk of crop failure in the ASALs (Stewart and Faught, 1984).

Under rainfed conditions, planting just before the onset of rains would guarantee crop harvest because of early establishment and growth before the period of moisture stress. Limited soil moisture and low crop yields discourage widespread use of fertilizer in the ASALs (Vlek*et al.,* 1981). However, with an ever-increasing demand for food, the potential of the drylands will need to be exploited to the fullest (FAO, 2005; Too and Onkware, 2002). With the introduction of drought tolerant crop varieties, fertilizer nitrogen has been used in an attempt to increase crop yield (Novoa and Loomis, 1981). The yield increase depends on the amount of soil water available at the time of fertilizer application (Nadar and Faught, 1984; Muli*et al.,* 2000). Nitrogen fertilizer promotes rapid leaf growth early in the season, thereby covering the soil surface and reducing evaporative losses (Gregory, 1989). Nitrogen is depleted from the soil at the rate of 40-100 kg/ha/year through various ways such as crop uptake, volatilization, leaching, wind and water erosion. There is therefore need for its replenishment (Sombroek*et al*., 1982; Vlek*et al.,* 1981; Rao and Muthuva, 2000). With adequate amount of soil moisture, yield response to nitrogen is significant. However during severe drought, fertilizer application may result in reduced yields (Wild, 1988).

Although beans can form nitrogen fixing symbiotic association with various rhizobia, they still require external supply of nitrogen at the early stage of establishment for maximum production (Simmonds *et al.,* 1999). The results by Too and Onkware (2002) shows that bean varieties GLP 1004 and GLP 585 could achieve good yields without fertilizer and thus suitable cultivars for ASALs (Maina*et al.,* 1997).

Water use efficiency is defined as the amount of dry matter produced per unit of water lost in both transpiration and evaporation (Sinclair *et al.,* 1984). It is difficult to determine crop transpiration accurately under field conditions. Most research has therefore tended to describe water use efficiency on the basis of evapotranspiration (ET). This can, with assumption be deduced from changes in the soil water profile (Bolton 1981; Pilbeam*et al*., 1995). The balance of water loss may be altered in favour of transpiration, by reducing losses through evaporation from the soil surface and drainage (Steiner, 1994). The choice of crop may also influence effective water use because of species differences in both root and shoot growth (Brown *et al.,* 1987; Brown *et al.,* 1989). Due to limited water availability in the ASALs the main focus in crop production is on the efficiency with which water is used (Gregory *et al.,* 2000). The crop that uses water most efficiently will be the one best adapted to ASALs (Gregory, 1988). Much of the rainwater received in the ASALs is inaccessible to the crop due to poor rainfall distribution and losses through runoff, drainage and surface evaporation (Rockstrom*et al.,* 1999; Malin*et al.,* 2001). Water use efficiency can be improved by increasing soil moisture storage and reducing evaporation losses, planting better adapted crop varieties and improved agronomic practices (Shangguan*et al*., 1999; Mahmoud and Chalavi, 2004).

This research was aimed at evaluating the response of common bean (*Phaseolusvulgaris L.*) to nitrogen fertilizer under semi-arid environmentin relation to the rainfall amount and distribution, for increased crop yields. The main objective of the research was to evaluate the performance of selected bean varieties at Longonot.The specific research objectives were to:

i. Evaluate the crop yield and water use efficiency in beans.
ii. Evaluate the yield of bean varieties under conditions of no nitrogen fertilizer and with nitrogen fertilizer in the semi-arid environment.

MATERIALS AND METHODS

Field experiments were carried out for two years at farmers' fields in Longonot, which has an average annual rainfall of 630 mm received in two rainy seasons. Short rains come in October – December, while the long rains come in March – May period. The long rains are more reliable than the short rains in terms of amount and distribution (Fig1). The soils are classified as Ando-CalcericRegosols and are shallow to moderately deep, 20-100 cm and are well drained. They are developed from volcanic ash and are highly susceptible to wind and water erosion, when vegetation cover is removed.

Longonot is a semi-arid area where people migrated in the 1970s from high rainfall areas in central province. When people settled in the area, the land use was changed from purely grazing to cultivated agriculture. Due to the low and poorly distributed rainfall, farmers have been experiencing frequent crop failure, inadequate food supply and low income level.

Three bean varieties were used for performance evaluate. The three bean varieties tested were Red Haricot commonly known as Wairimu (GLP 585), Mwezimoja (GLP 1004) and Mwitemania (Pinto).The experimental design was randomized complete block laid as split plot and replicated three times. Nitrogen fertilizer was applied to the main plot while bean varieties were allocated to the sub-plots. The sub-plots were 5 m by 4 m and spacing was 45 cm by 10 cm between and within rows, respectively. Two seeds per hole were planted and later thinned to one plant, resulting in a population of 110,000 plants/ha. Phosphorus was applied at the time of planting as a basal fertilizer in all research plots as triple superphosphate (TSP) at the rate of 18 kg P/ha to supplement phosphorus. Nitrogen fertilizer was applied to the main plots as urea (46 % N) at 0 and 18 kg/ha. The application was done in two equal splits as side dressing soon after rains at around 20 and 40 days after emergence.

Cumulative dry matter was determined by harvesting four plants per plot at fifteen-day intervals after emergence. The fresh weight was recorded and a sample of chopped plants was dried in the oven at 80 ^{o}C for 24 hours to a constant weight. The grain yield was determined by harvesting one square metre at the middle of the plot in all the plots. The bean seeds were separated by hand and the seed dry weight was adjusted to 12 % moisture content. Water use efficiency was calculated by dividing the total grain or seed yield (kg/ha) by the total rainfall received during the entire cropping period (Bolton, 1981). The data was analysed using Genstat version 6.1. Analysis of variance (ANOVA) was done and the means separated using least significant difference (LSD). The coefficient of variation (CV %) was used as an indicator of error variance due to soil or other differences within the research site (Kelly *et al.,* 2001). Since it is impossible to control all variability, a CV value of 10 % or less implies excellent error control and is reflected in lower LSD values (Steel and Torrie, 1981).

RESULTS AND DISCUSSIONS

Within the two years of field research, planting of beans was done in four seasons, short rains; October 2002-February 2003, October 2003-February 2004, and long rains; March-September in 2003 and 2004. Beans were harvested in three seasons; one short rain season (2002/2003) and the two long rain seasons (2003 and 2004). The short rain season of 2003/2004 was a total crop failure and the crop dried within 20 days after emergence due to inadequate rainfall (Fig 2 and Fig 3).

Rainfall analysis at Longonot indicated that the highest amount of rainfall was received within the first month of bean crop development. Bean is a short duration crop and mostly matures in two and a half months. Bean growth was divided into two major phases, phase (I) before 50 % flowering, which was mainly vegetative growth and the reproductive phase (II) after 50 % flowering up to full maturity. About 80 % of seasonal rainfall in both 2003 and 2004 was received before 50 % flowering, while 20 % was received after 50 % flowering. In the three seasons that beans were harvested (SR 2002, LR 2003 and LR 2004), the crop experienced water stress at around flowering or just immediately after 50 % flowering. This is a critical stage that determines the final yield (Fig 4). Although there was no significant difference ($P \leq 0.05$) in phenological changes among the varieties, GLP 1004 had a longer flowering period and matured earlier than the two other varieties. It also emerged slightly earlier after sowing than the other varieties (Table 1).Total dry matter (TDM) yields of the three bean varieties increased from emergence and reached maximum at physiological maturity. The increase was almost linear during the vegetative phase and at diminishing rate during the reproductive phase (Fig 5).

Bean crop was harvested for three seasons (SR 2002/2003, LR2003 and LR 2004) out of four. There was total crop failure in one short rain season (October 2003-March 2004) due to very low seasonal rainfall (201 mm). Pinto had the highest yield in all the three harvested seasons compared to the two other varieties. There was significant difference ($P \leq 0.05$) in yield between GLP 1004 and GLP 585 (Table 2).

There was positive correlation between seed yield and the amount of total rainfall and between seed yield and rainfall amount before and after 50 % flowering. This implies that there was variation of seed yield due to rainfall distribution. The highest variation was due to rainfall after 50 % flowering, which is the reproductive phase. The total rainfall and the amount before 50 % flowering had almost the same influence on yield variation (Fig6). The critical period of high crop water requirement was after 50 % flowering where the water stress during this period would lead to low yields. The seed yield would almost double (4 kg ha^{-1} mm^{-1}) with more rain after 50 % flowering than the total seasonal rainfall or rain before 50 % flowering.

There was no significant difference ($P \leq 0.05$) in yield response to nitrogen fertilizer application in all the three harvested seasons (Fig 7), due to insufficient rainfall that was 205 mm, 504 mm and 189 mm in SR 2002/2003, LR2003 and LR 2004 respectively.

CONCLUSION

There was no significant yield response to fertilizer application at Longonot due to low and poorly distributed rainfall. Water availability was therefore more critical in yield increase than fertilizer application. Water harvesting technology like tied ridges would increase soil moisture storage and hence crop yields.

There was no significant difference in phenological changes amongst the bean varieties. Flowering for all the varieties was within one month after emergence. Bean is a short duration crop and the chance of harvesting a crop was higher than for maize that takes longer to reach physiological maturity. The seed yield among the varieties was not significantly ($P \leq 0.05$) different and so the choice of varieties would depend on farmers' preference.

The amount of soil moisture and its distribution was a more critical factor in yield response than fertilizer application. Bean crop has high probability of getting harvest because it reaches reproductive phase before soil moisture is heavily depleted. The soil water demand of beans is also lower than that of maize.

ACKNOWLEDGEMENTS

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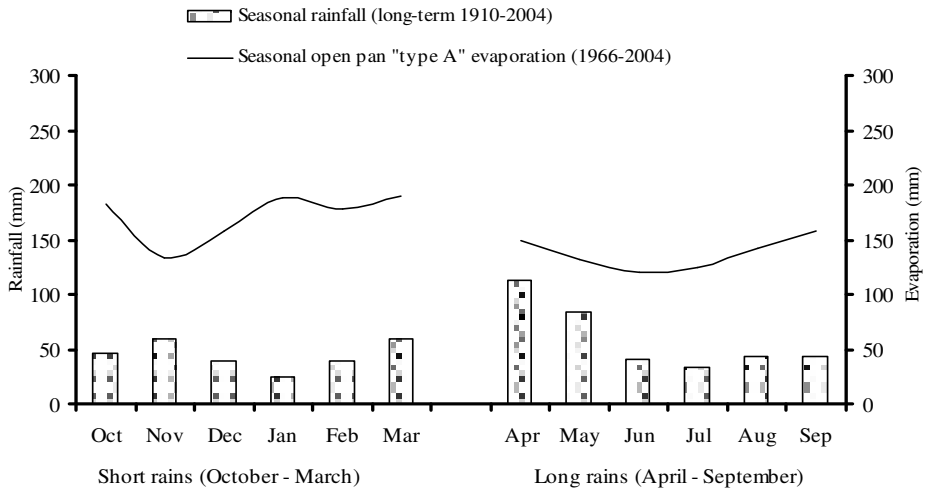

Fig 1. Long-term (39 years) monthly rainfall distributions and open pan evaporation during short and long rain seasons at Longonot.

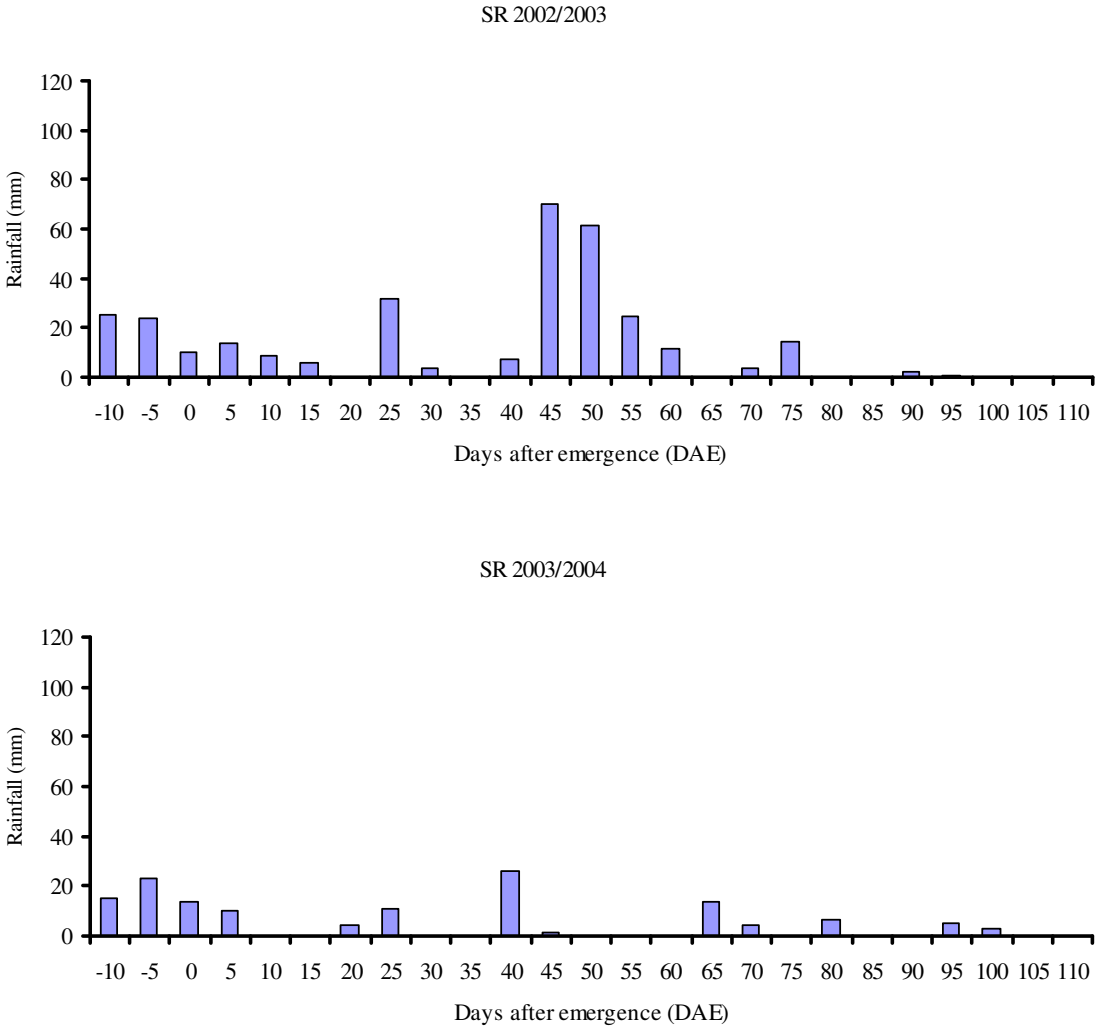

Fig 2. Rainfall distribution (5 day totals) during two short rain (SR) seasons in (a) Oct.2002-March 2003 and (b) Oct. 2003-March 2004 at Longonot. Negative sign indicates days before sowing.

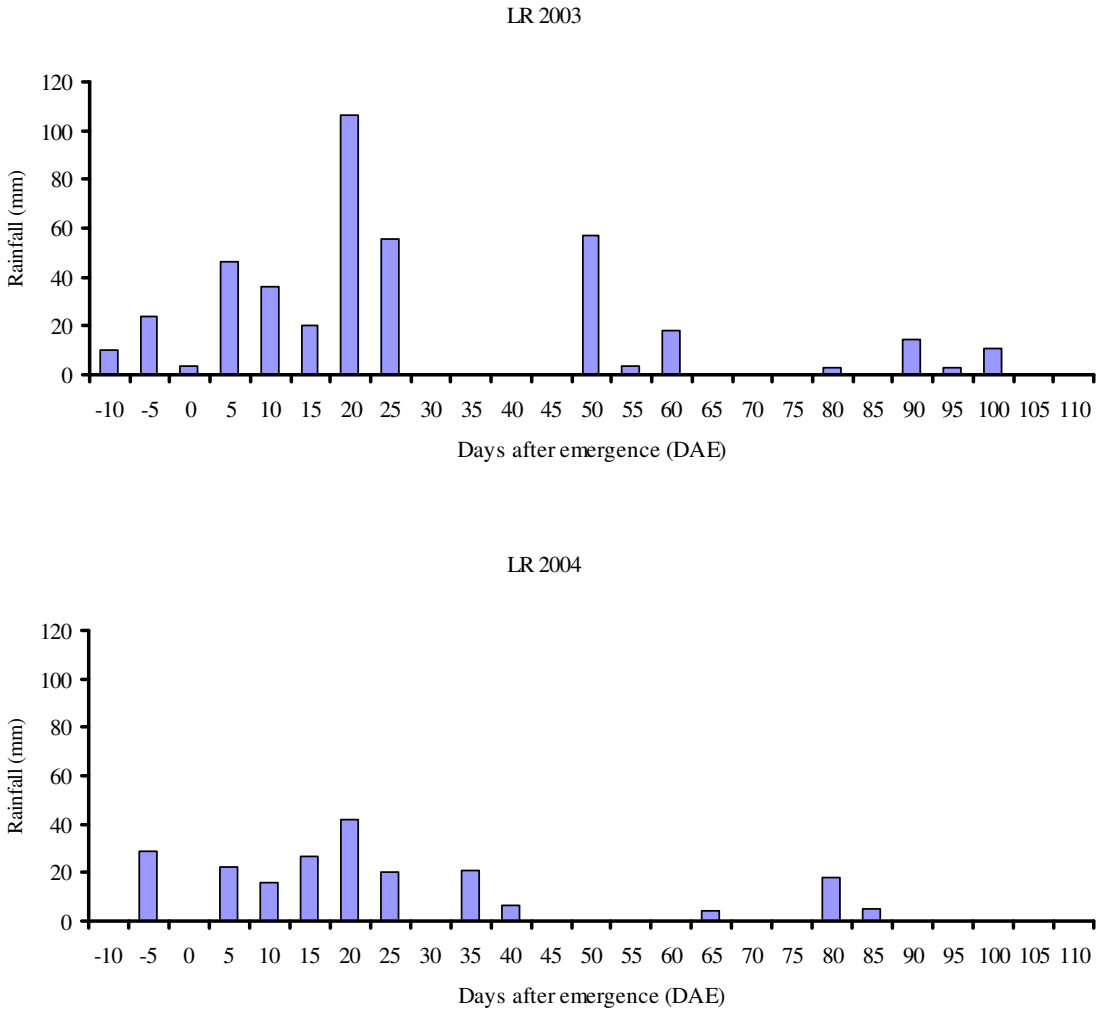

Fig 3. Rainfall distribution (5 day totals) during long rain (LR) seasons in April-September (a) 2003 and (b) 2004 at Longonot. Negative sign indicates days before sowing.

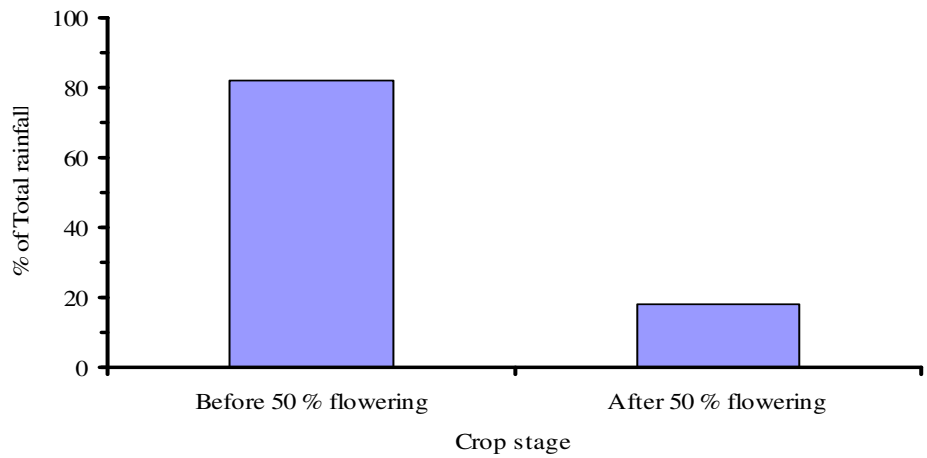

Fig 4.Seasonal rainfall distribution and bean growth stages.(Pooled data in LR 2003 and 2004) at Longonot.

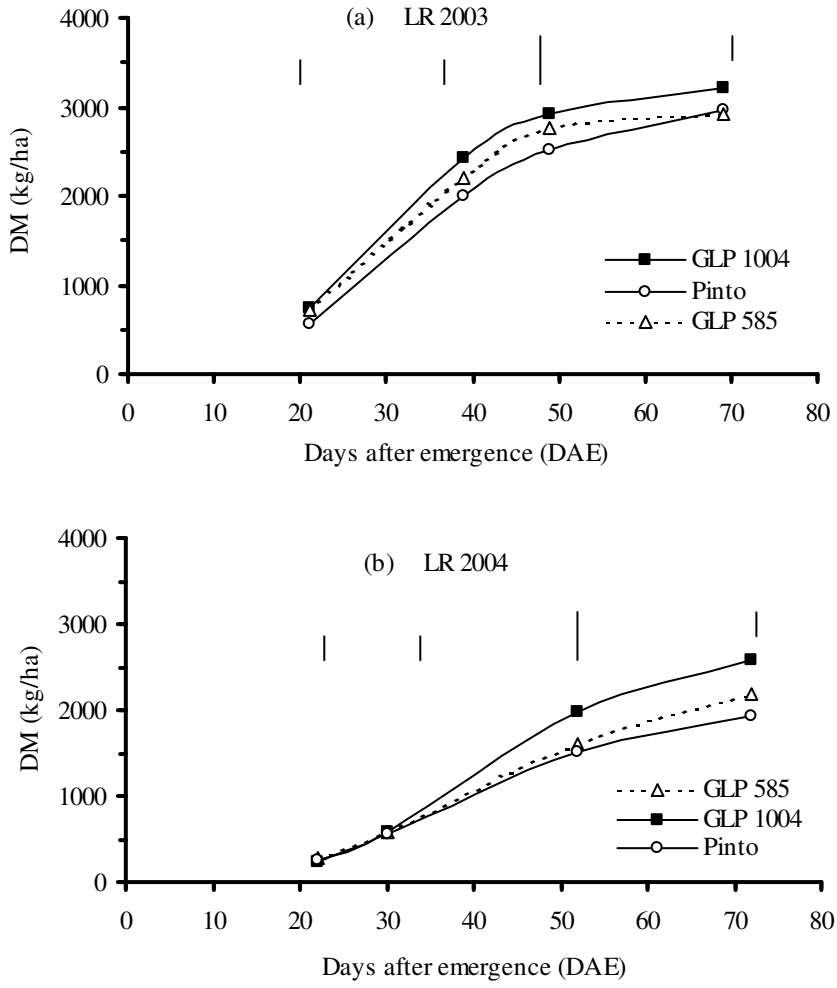

Fig 5. Cumulative dry matter yield of three bean varieties in (a) 2003 and (b) 2004 long rain seasons at Longonot. The error bars represent least significant difference (LSD) of means ($P<0.05$).

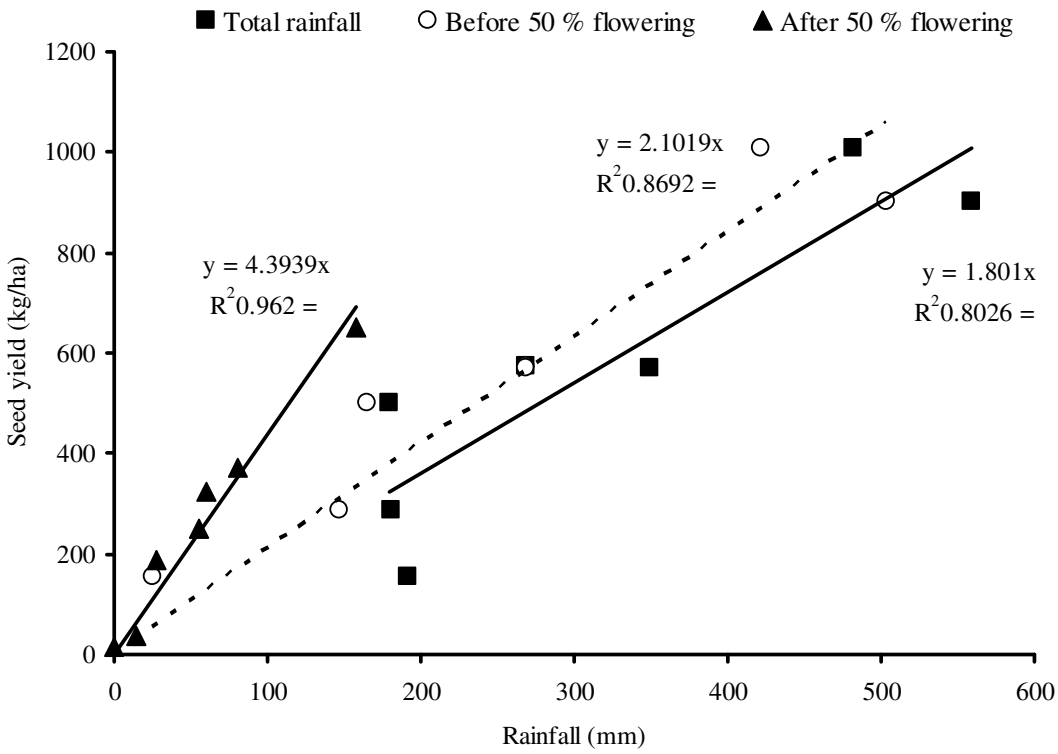

Fig 6. Influence of seasonal rainfall distribution on bean yield (a) total rainfall (b) rainfall before 50 % flowering and (c) rainfall after 50 % flowering (pooled data for 2003 and 2004) at Longonot.

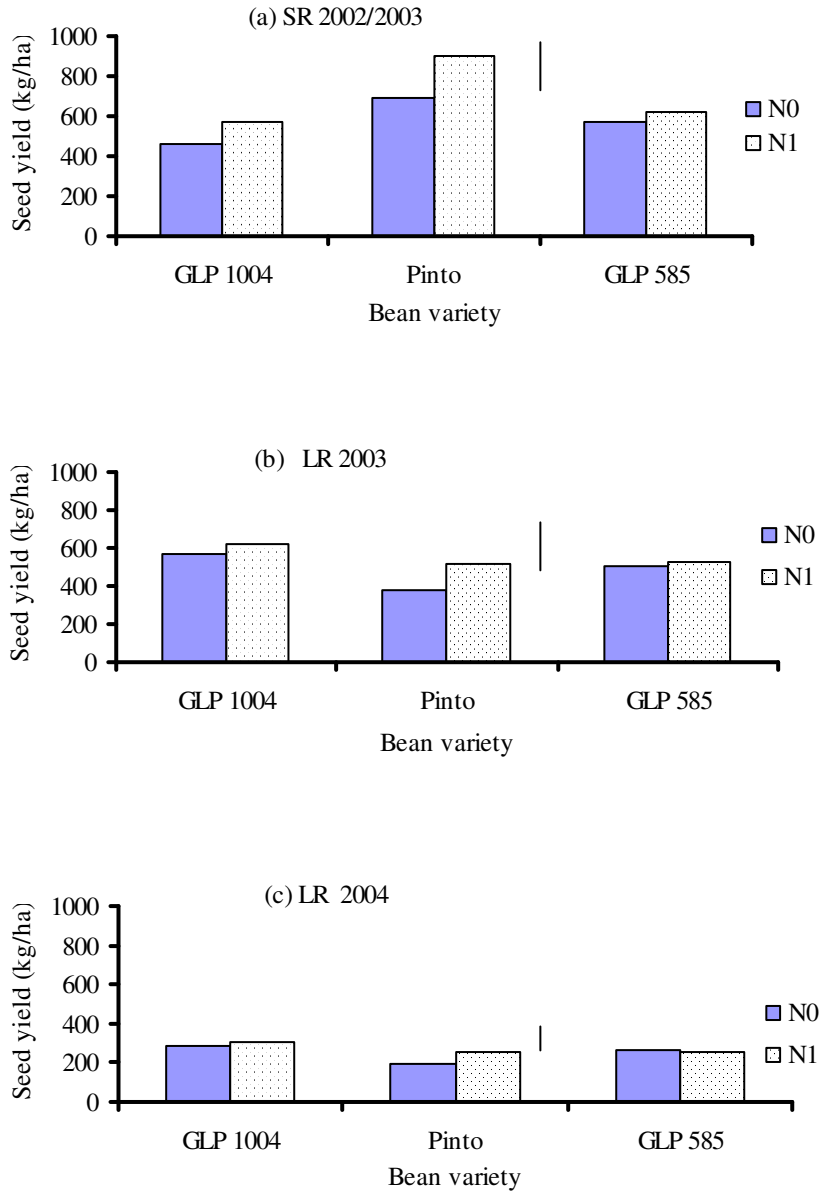

Fig 7. Bean yield response to nitrogen fertilizer in (a) short rains 2002/03, (b) LR 2003 and (c) LR 2004 at Longonot. The error bars represent least significant difference (LSD) of means ($P \leq 0.05$). N0 = 0 kg N/ha and N1 = 18 kg N/ha

Table 1. Phenology of three bean varieties in LR 2003 at Longonot.

Variety	Days to 50 % emergence	DAE to 50 % flowering	DAE to 50 % podding	DAE to physiological maturity
GLP 1004	7	34	39	67
Pinto	6	32	39	62
GLP 585	7	31	39	66
LSD	1.1	0.65	1.81	1.5
CV%	10.9	1.3	2.1	1.3

Table 2. Seed yield (kg/ha) of three bean varieties in three seasons at Longonot

Variety	SR 2002	LR 2003	LR 2004
GLP 1004	630	493	280.5
Pinto	925	660	330.1
GLP 585	705	561	246.4
LSD	83.1**	69.5 ^{ns}	34.8*
CV%	14.2	11.2	10.2

Note: * =Significant difference ($P \leq 0.05$)

** = Significant difference ($P \leq 0.01$)

^{ns}= not significant

LR = Long rains

SR = Short rains

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Witness Protection Socio Cultural Dilemmas

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ABSTRACT

This paper focuses mainly on key socio-cultural dilemmas critical to any Witness Protection Program, a study on Kenyan Witness Protection Program is used to bring forward the issues that need to be observed when reviewing or developing a Witness Protection Program. The study aimed to examine the socio-cultural factors influencing protection of witnesses. Data was collected from Kenya's criminal Justice agencies concerned with the implementation of the Witness Protection program; two methods of data collection were used. They include: in-depth interviewing and document analysis. The number of participants was determined by those who were likely to yield information being sought. Top five informants were selected from each eight selected agencies since they are better placed to give the relevant information. The study revealed that cultural diversity influence the appearance and testifying of witnesses within the court process.

Key words: Witness Protection Socio Cultural Dilemmas

1.0 Introduction

The term "witness" may vary depending on the context being discussed. For protection purposes a witness is any person in possession of information vital to the judicial or criminal proceedings – that is relevant rather than his or her status or the form of testimony. With regard to the procedural moment at which a person is considered to be a witness, the judge or prosecutor does not need to formally declare such status in order for protection measures to apply. Witnesses can be classified into three main categories: justice collaborators; victim-witnesses; and other types of witnesses (innocent bystanders, expert witnesses and others) (UNODC, 2008) which this study explored also in line with the Witness Protection Program in Kenya.

Recognizing the need to provide for the well-being of victim-witnesses and aware that the admission criteria of witness protection programmes are overly rigid, a number of countries have introduced special witness assistance or support schemes that are distinct from witness protection. Implemented in close cooperation with law enforcement, judiciary and immigration authorities and civil society, such schemes aim to create the conditions that would allow vulnerable witnesses not only to testify in physical security but to avoid re-victimization as well. They include: police protection, temporary relocation to safe areas, evidentiary rules of protection measures when testifying in court (anonymity, shielding, videoconferencing), and moderate financial assistance. This study explores the trend in Kenya and the issues the Witness Protection program has in terms of supporting witnesses' with socio cultural Challenges.

1.1 Problem analysis and objectives

Examination and cross-examination is of necessity and demanding but can leave witnesses feeling bruised and vulnerable, especially when judges do not intervene to prevent harassment of witnesses (Ellison, 1998). Yet it is also clear from studies on giving evidence at all stages of the criminal process, but more particularly in court, that witnesses who are relaxed and who feel secure are more likely to recall key events accurately and to give their evidence in a lucid and consistent way (Memon et al., 1998). This study identifies the state of a witness where he/she doesn't feel socio-culturally harassed during the proceedings as a way of getting the reliable information form the witness.

2.0 Witnessing in Criminal Justice Systems

Witnesses' accounts in court can be a decisive factor in determining the outcome of a case. Increasingly, inquisitorial systems are also relying on oral evidence from witnesses (as is clear from the line of cases regarding witnesses that have been referred to the European Court of Human Rights) The role of the witness can be a demanding and stressful one. Research in a variety of jurisdictions has demonstrated that witnesses seldom find witnessing a positive experience (Rock 1993; Stafford & Asquith 1992; Goodman et al. 1992b). They may not know what is expected of them and most are unlikely to find the laws of evidence and procedure easy to understand. Some may complain of aggressive and intensive cross-examination. They may have to wait for long periods in unfamiliar environments and they may have little guidance about what is likely to happen or explanations for the decisions and outcome in their case. Reluctant witnesses, who may have genuine reasons for fearing retaliation or cultural harassmentif they give evidence, are not infrequently treated as disobedient and penalized accordingly (Fyfe and McKay, 2000). This study explores witness protection programme which helps witnesses who have fear of intimidation especially from people in power and those who are culturally connected to them.

2.1 Witness Rights and Responsibilities

In spite of these difficulties, the position of witnesses in most jurisdictions revolves around responsibilities rather than rights (Mackarel *et al.,* 2001). For instance, in Scotland at the present time, witnesses must give statements to the police when asked to do so. In serious cases they must agree to be interviewed by the prosecutor and in all cases they must allow the defence to interview them. They must give their names and addresses even in circumstances where they would prefer to remain anonymous because of fear of intimidation. In addition, they must make themselves available to be examined and cross-examined in court, regardless of whether the date, location and mode of giving evidence are suitable for them. The requirement to comply with a witness citation to appear in court in a serious case has been strengthened in various countries by certain provisions, where witness's arrests are to be issued in special cases, for example, as it is the case in Scotland. Some recognition however, has been given to the problems faced by certain witnesses in giving evidence. For example, the Council of Europe has acknowledged the needs of intimidated witnesses, particularly in cases of organized crime or crime against the family, in a wide-ranging Recommendation on the Intimidation of Witnesses and the Rights of the Defence (Moody, 2005). This study looks at the position of the witness whether it is right or responsibility as it is the case in Scotland paying attention to Witness Protection Program and also socio-cultural aspects are significant from the witness's point of view.

2.2 Scotland's' Context

In Scotland, alternative ways of giving evidence (using what are called "special measures") have been available to children since 1990. Children (defined on those aged less than 16 years old) may in any criminal case, give their evidence from behind a screen, by CCTV, or by means of a commissioner, subject to judicial approval. In 1997, this legislation was extended to include a limited range of vulnerable adults, namely those with certifiable mental illnesses or with severe learning disabilities. A complete revision of this area took place between 1998 and 2003, involving an extensive consultation exercise with interested parties (Scottish Office, 1998; Scottish Office, 2002) and culminating in the Vulnerable Witnesses (Scotland) Act 2004. This study examines problem faced by witnesses especially the vulnerable group women and children who need more of protection.

2.3 Witnessing and Justice

The crucial part played by witnesses in bringing offenders to justice is central to any modern criminal justice system, since the successful conclusion of each stage in criminal proceedings, from the initial reporting of the crime to the trial itself, usually depends on the cooperation of witnesses. Their role at the trial is particularly important in adversarial systems, where the prosecution must prove its case by leading evidence, often in the form of oral examination of witnesses, which can then be challenged by the defence, at a public hearing. Psychological studies of evidence-giving (Memon et al., 1998; Dent and Flin, 1992) suggest that court appearances can be highly stressful for witnesses, even in comparatively minor cases. The layout of the courtroom designed to be imposing and even intimidating, can be a source of fear but even more daunting is the nature of the proceedings, which may be incomprehensible to lay witnesses (Rock, 1991). This study scrutinizes this and appreciates the need to have a new layout of our courtrooms to encourage the witnesses who feel intimidated to testify sine they form a crucial part of any criminal proceedings.

2.4 Kenya's Witness Protection Program Focus

The major goals of Kenya's Witness Protection Program focuses in the preparation of Witnesses for court, facilitate truthful testimony and help protect the witnesses' self-esteem, personal integrity and promote sense of self-worth and confidence during witnessing process. This study looks at how women and children are treated due to their vulnerability and social-cultural factors which make them feel threatened. Witnesses make a vital contribution to many criminal cases. Their role is particularly significant in Kenya's legal systems where the focus of trial proceedings is on oral evidence (Egglestone, 1978).

2.5 Vulnerable witness before court

Jurors have a reasonably accurate perspective about many areas of eyewitness research, but jurors, Magistrates and judges, have misconceptions about a number of witness issues, including misconceptions about vulnerable witnesses such as Child witness. In an ideal Child Witness Program, every child called upon to testify should: Be treated with respect during his or her involvement in the criminal justice system, feel safe and protected in a courtroom, have court preparation tailored to his or her individual needs have easy access to testimonial aids, be questioned by adults who adapt their communication to his or her developmental age and linguistic ability and have his or her special needs met and vulnerabilities addressed. In Kenya the Witness protection program has not fully factor handling of vulnerable witness particularly the minors, people with disabilities and gender minority groups. (Gay, lesbian and transgender).This study explores the capacity gaps with courts when dealing with children and other vulnerable witnesses with specific social-cultural needs.

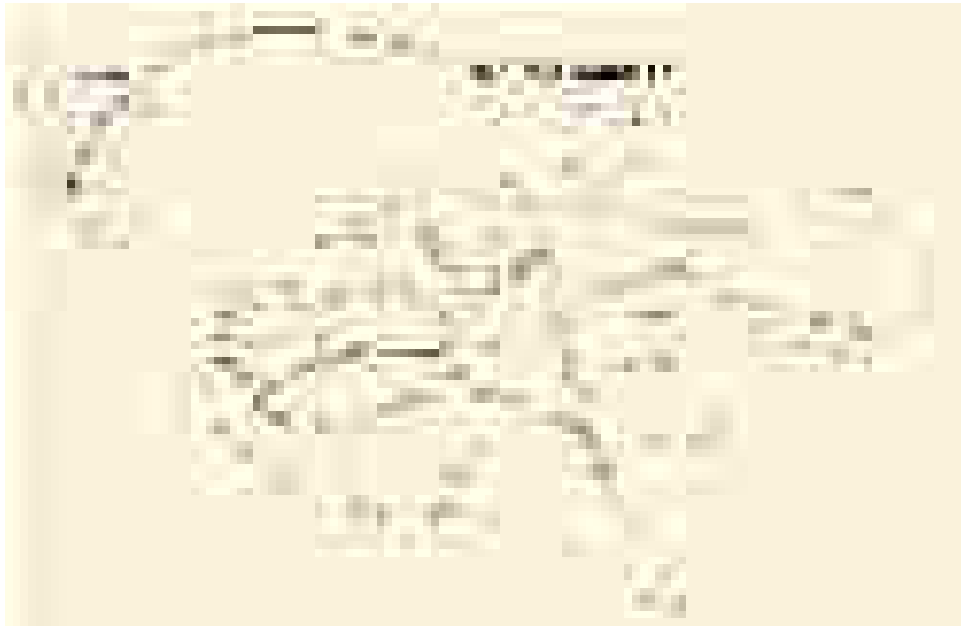
2.6 Theoretical Framework

This study is premised on the structural functionalism theory. Structural functionalism, or simply functionalism, is a framework for building theory that sees society as a complex system whose parts work together to promote solidarity and stability (Macionis, 2010). This approach looks at society through a macro-level orientation, which is a broad focus on the social structures that shape society as a whole, and believes that society has evolved like organisms (DeRosso, 2003). This approach looks at both social structure and social functions. Functionalism addresses society as a whole in terms of the function of its constituent elements; namely norms, customs, traditions, and institutions. Regarding to Witness Protection structural fundamentalism ensures that all societal factors such socio cultural elements are considered during the development and implementation of Witness Program for it to be effective

3.0 Methodology and Scope

This study was carried out at the judicial and legal institutions within Nairobi county. The key departments targeted were: the Attorney General office, the Law Society of Kenya, The Directorate of Public Prosecution, the Kenya Police, The Ministry of Gender (Children's Department), Directorate of Witness Protection Agency, the Children's Court, and the representatives from the National Assembly. Secondary data was collected from case related legislative provisions and reports from national and international agencies advocating for human rights within Nairobi County.

Figure 1.0 below shows the map of the study area.



Source: Writer (2015)

3.1 Study Sampling

The sample for the study was drawn through purposive sampling. According to Kothari (2008), purposive sampling is ideal when the researcher intends to pick up subjects for the study that meet a defined criterion. The researcher applied this approach to select key informants from the Attorney General office, the Law Society of Kenya, The Directorate of Public Prosecution, the Kenya Police, The Ministry of Gender (Children's Department), Directorate of Witness Protection Agency, the Children's Court, and the representatives from the National Assembly. Being a non-probabilistic and subjective approach, the researcher intended to reach out to at most 40 key informants.

3.2 Study Design

The study adopted a case study design. A case study approach was necessary considering the nature of the target respondents. The research utilized a case study design and qualitative mode of inquiry.

4.1 Results and discussions

4.1.1 Introduction

The broad objective of this study was to examine the socio cultural factors critical to the implementation of Witness Protection Program in Kenya. Specifically, this study sought to examine the socio-cultural dilemmas influencing protection of witnesses.

4.1.2. General Information of the Sample

Data for this study was collected from 40 key informants who directly handle witness protection issues. The sample was largely male-dominated with 85% of the sampled respondents being male respondents and the remainder of 15% being female. The gender distribution is shown in Table 4.1.

Table 4.1: Distribution of Sample Respondents by Gender

Gender Category	Number of Respondents	% of the Total
Male	34	85.0%
Female	6	15.0%
Total	40	100.0%

The respondents were drawn from the Attorney General's office, the Law Society of Kenya, The Directorate of Public Prosecution, the Kenya Police, The Ministry of Gender (Children's Department), Directorate of Witness Protection Agency, the Children's Court, and the representatives from the National Assembly. The researcher spent considerable time at offices identifying key informants (especially key strategists) who were involved with the formulation of the witness protection programmes, reading the current and past correspondence dealing with the formulation of policies leading to the programme, and having extensive discussions with key informants. Table 4.2 indicates the distribution of the respondents by the source institutions from where they were sampled from.

Table 4.2: Respondent Distribution by Source Organization

Agency	Number of Respondents
Attorney General Office	5
Law Society	5
Directorate of public prosecution	5
Ministry of Gender	5
Directorate of witness protection agency	5
Children's court	5
Kenya police	5
National Assembly	5
Total	**40**

A majority of the sample respondents had extensive experience in civil and criminal litigation issues, public policy formulation, and legislative procedures. All respondents had over 3 years working experience in each of these three core areas under review, with a majority of the respondents (60%) being in the 6-10 years' experience bracket. These results are tabulated in Table 4.3 below.

Table 4.3: Distribution of Sample Respondents by Level of Experience

Years of Experience	Number of Respondents	% of the Total
0 – 2 years	-	-
3 – 5 years	6	15.0%
6 – 10 years	24	60.0%
Over 10 years	10	25.0%
Total	**40**	**100.0%**

4.1.3. Socio-Cultural Barriers Influencing Protection of Witnesses

Witnesses cannot be separated from their family members forever. In the early year of witness protection, little attention was given to the maintenance of relations between witnesses and the persons close to them. As a result, participants would often walk out of the programme or compromise security by trying to contact relatives or partners. Witness protection programmes have adapted to meet that need by extending protection to the witness's family members, cohabitants and other persons close to him or her. The number of persons that may accompany a witness in the programme depends, in part, on factors such as family traditions and social culture. Witnesses with strong social and family links pose a range of additional difficulties that must be considered during the assessment process. Ultimately, other measures may have to be taken to ensure protection. Alternatively, the decision may be taken to exclude that person as a witness. One key group that must be considered when relocating persons close to the witness is young children, who may compromise the programme by revealing confidential details to outsiders. Witnesses cannot be separated from their family members forever. In the early years of witness protection, little attention was given to the maintenance of relations between witnesses and the persons close to them. As a result, participants would often walk out of the programme or compromise security by trying to contact relatives or partners.

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Table 4.4: Socio-Cultural Barriers Influencing Protection of Witnesses

Cited Barriers	Number of Respondents	% of the Total
Strong cultural bonds among kinsmen	13	32.5%
Fear of possible identity change	7	17.5%
Victims/ witnesses may not be cooperative	12	30.0%
Prohibited cultural topics of discussion	8	20.0%
Perceived prohibition for women to testify	4	10.0%
Curse threat on testifying against practices	2	5.0%

*** Each row is based on multiple responses (out of 40 sampled informants)**

Today, in organized crime cases, witness intimidation is becoming so widespread that if there are not several witnesses to the crime, prosecutors do not pursue a court case. Persuading witnesses to testify on behalf of the prosecution sometimes becomes one of the most important obstacles prosecutors encounter in court cases when the defendant has an association with an organized crime group. Organized crime groups have effectively paralyzed the criminal justice system by threatening retribution toward anyone who attempts to testify against them. This study also sought to identify ways in which cultural diversity influence the appearance and testifying of witnesses within the court process. The findings are tabulated in Table 4.5 below.

Table 4.5: Ways in Which Cultural Diversity Influences Witness Participation

Cited Barriers	Number of Respondents	% of the Total
Cultures prohibit open courts testifying	16	40.0%
Cultures prohibit women to testify	7	17.5%
Young men do not testify against old men	7	17.5%
Co-operation with law enforcers a taboo	7	17.5%
Tribalism: perceived tribal rivalry	12	30.0%

*** Each row is based on multiple responses (out of 40 sampled informants**

5.0 Conclusion and Recommendations

Issues to be addressed in this regard include: expanding natural adhesion to fight tribalism; inculcate moral values among Kenyans; let them recognize that a crime is a crime even when perpetrated by tribesmen; trained translators to invest in equipment for example, audio and video recorders; ensure confidentiality and privacy of witnesses and victims of crime. Civic education and awareness campaign was also a major recommendation, as suggested by 62% of the respondents. The following are key recommendations made:

1. Sensitizing Kenyans on the advantages of witness protection and the need to give evidence as required. Kenyans should work hand in hand with security organs, and their attitude towards the programme should be targeted. Negative feelings about the law enforcement should be discouraged. Education on elimination of negative cultural practices should be paramount.

2. Police and other law agencies must be friendly with the general public to encourage community policy in the fight against crime. Agencies should take advantage on the many vernacular radio and television stations and sensitize people on witness protection Programme, and decentralize to the smallest unit i.e. sub-locations and ensures the local understand their mandates.

3. Witness to be informed on cultural change in case of relocation. Also, proper explanation to the witness of the court process after recording a statement. It was also suggested that negative cultural activities that impede justice to be discouraged.

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Thermodynamic Modelling of Molten Salt Thermal Energy Storage System

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Abstract

This paper presents a novel methodology for comparing thermal energy storage to electrochemical, chemical, and mechanical energy storage technologies. The underlying physics of this model is hinged on the development of a round trip efficiency formulation for these systems. The charging and discharging processes of compressed air energy storage, flywheel energy storage, fuel cells, and batteries are well understood and defined from a physics standpoint in the context of comparing these systems. However, the challenge lays in comparing the charging process of these systems with the charging process of thermal energy storage systems for concentrating solar power plants (CSP). block. The round trip efficiency and the levelized cost ofenergy (LCOE) are the metrics used for comparison purposes. The thermal energy storage system is specifically compared to vanadium redox,sodium sulphur,and compressed air energy storage (CAES) systems from a large scale storage perspective of 100's of MWh. The results from the modelling using Andasol 3 CSP plant as a case study yield a storage efficiency of 86% and LCOE of $216/MWh.It is anticipated that the results of this modelling will facilitate the future generation of a thermal energy storage roadmap.

Keywords: efficiency, thermal, energy, storage, exergy, LCOE

1. Introduction

The development of the round trip efficiency thermodynamic model for TES will serve as a platform for comparing TES to other electrical storage technologies from a performance and cost efficiency standpoint.Round trip efficiency is the usualperformance metric in all storage systems including thermal energy storage systems. There are three formulations of round trip efficiency in TES systems namely the first law efficiency, second law efficiency, and storage effectiveness [1].These formulations are not adequate for comparison to other electrical storage technologies, as these efficiencies are in the form of the ratio of thermal energy output to thermal energy input.This formulation methodology makes it difficult to compare TES to electrical storage technologies, asthe formulation takes the form of the ratio of electrical energy output to electrical energy input. The analysis done in this paper presents a creative methodology of formulating the round trip efficiencyof a molten salt storage system, such that it can be compared to electrical storage technologies from an electrical energy perspective. The comparison is specifically made to vanadium redox batteries, sodium sulphur batteries, and compressed air energy storage, as these systems have large scale storage capabilities of hundredsof MWh. Modelling and simulation of TES integration in a CSP plant is essential in analysing the performance of TES systems. Storage sizing methodologies that do notincorporate performance cannot adequatelydepict the losses and usability [1]. The integration of TES and its design considerations have been discussed [2].

TES system integration in a CSP plant effectively provides power on demand during night hours and economic benefit to CSP power producers by incorporating the time of day tariff. The performance metric of round trip efficiency and the cost metric of levelized cost of energy (LCOE) are essential parameters for

comparing TES systems to electrical storage systems through the development of a comprehensive thermal energy storage system that would entail performance, cost, technological readiness levels, and an economic and policy framework for TES technologies. A fleet of TES technologies have beeninvestigated for performance and cost efficiency [3-7]. It is anticipated that there will be aneedto develop cost efficient TES systems complemented with low melting point and high temperature materials research for the future.

NOMENCLATURE

η	Roundtrip efficiency [%]
η_{hx}	Thermal efficiency of the heat exchanger [%]
A_{ref}	Reference area [m^2]
C_P	Specific heat capacity [J/kgK]
$E_{out,ws}$	CSP output energy with storage [J]
$E_{out,ns}$	CSP output energy without storage [J]
FCR	Fixed charge rate
ΔG_d	Exergy destruction during discharge [J/kg]
ΔG_c	Exergy consumption during charge [J/kg]
h	Enthalpy [J/kg]
IC	Investment cost [US Dollars]
L	Height of the tank [m]
msalt	Mass of molten salt [kg]
m_{HTF}	Mass of HTF [kg]
p	Perimeter of the round tank [m]
$Q_{loss,top}$	Heat lost through the top of the cylinder [J]
$Q_{loss,cond}$	Heat lost through the foundation [J]
$Q_{loss,env}$	Heat lost through the sides [J]
Qdot	Rate of heat lost [W]
$T_{out,st}$	Temperature of the hot tank [K]
$T_{in,st}$	Temperature of the cold tank [K]
$T_{out,HTF}$	HTF outlet temperature [K]
$T_{in,HTF}$	HTF inlet temperature [K]
T_H	Maximum temperature reached during charging [K]
T_m	Temperature of the tank [K]
T_{amb}	Ambient temperature [K]
Ttank(x)	Temperature variation along the height of the tank [K]
T_{env}	Temperature outside the tank [K]
Uoverall	Overall heat transfer coefficient [W/m^2K]
U(T)	Sensible energy storage expression [J]

2. Methodology

Figures 1 to 4 compare the charging and discharging processes of batteries and fuel cells, compressed air energy storage, flywheel energy storage, and TES in order to derive the round trip efficiency formulation. Figure 1 to 3 define efficiency simply as the ratio of electrical energy output to electrical energy input, as shown in Figures 1 to 3. The input energy is equivalent to the energy of a system without storage in Figures 1 to 3. The input source of energy is electrical energy in Figures 1 to 3 except for Figure 4, where the input is thermal energy. The very same stipulation holds for TES and is demonstrated by taking the energy ratio of a CSP system with storage divided by a CSP system without storage, as shown in Figure 4. The ratio obtained equals the thermal storage efficiency.

The block diagrams of Figures 1 to 3 show the representative values of round trip efficiency for these systems garnered through literature. Figure 1 shows a simplified charging and discharging cycle of a battery and fuel cell. Figure 2 shows electrical energy fed into a compressor which drives the air into a cavern/vessel, which is later discharged due to peak demand. Figure 3 shows electrical energy driving a motor/generator system that spins a flywheel. This later drives the generator because of the inertia of the flywheel during the discharge cycle. Figures 4 and 5 illustrate the mechanismof a parabolic trough CSP plant with storage. Round trip efficiency is expressed as follows in Figures 1 to 4:

$$\eta = \frac{Eout,ws}{Eout,ns} \quad (1)$$

This performance metric expression provides a compact way to compare TES to electrical storage technologies from an electrical energy standpoint.

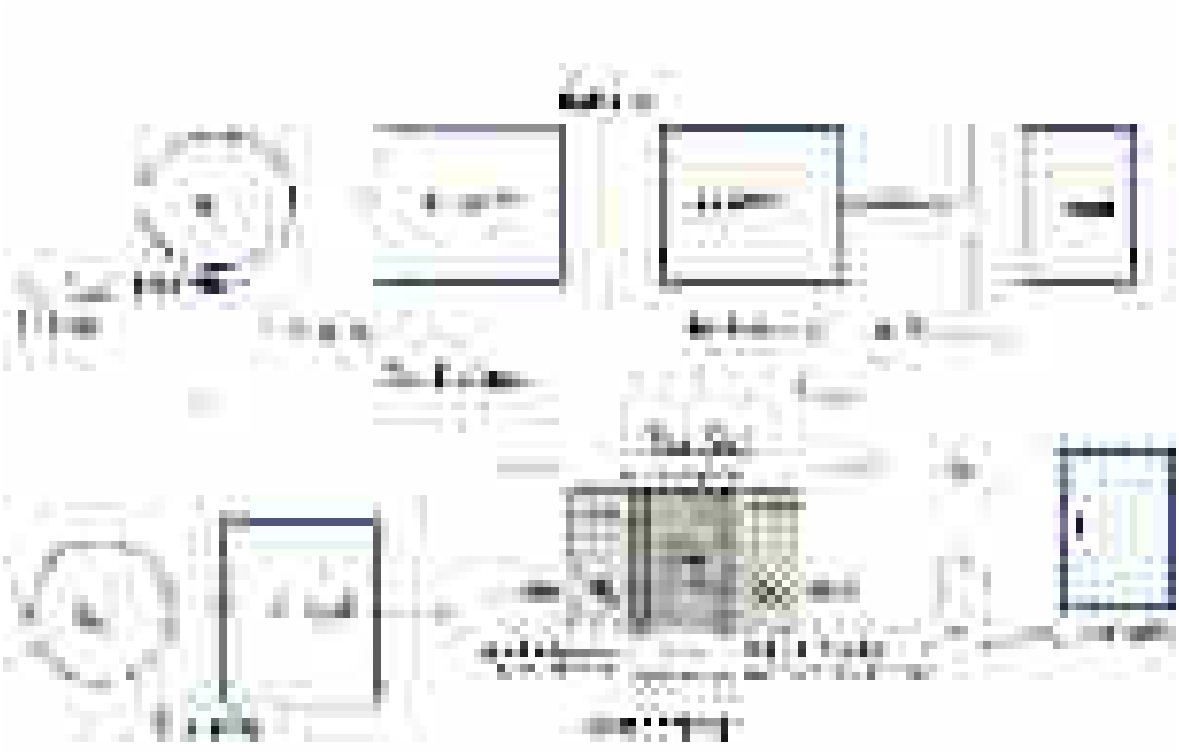

Figure 1 Charging and discharging processes of batteries and fuel cells.

The round trip efficiencies of batteries are shown in Table 1.

Table 1 Round trip efficiencies of batteries [20].

Battery	Round trip efficiency
Vanadium redox	75-85%
Lead acid	70-90%
Sodium sulphur	80-90%
Lithium ion	85-90%
Nickel cadmium	60-65%

Figure 2 Charging and discharging processes of CAES.

Figure 3 Charging and discharging processes of flywheel energy storage.

Figure 4 Charging and discharging processes of a CSP plant with and without storage.

Figure 5 Andasol-1 CSP plant layout [21].

2.1 Energy Analysis and LCOE Formulation

The thermodynamic model comprises the governing equations of heat transfer between heat transfer fluid (HTF) and molten salt storage; heat exchanger losses; and molten salt storage tank losses. Figure 6 shows the oil to salt heat exchanger.

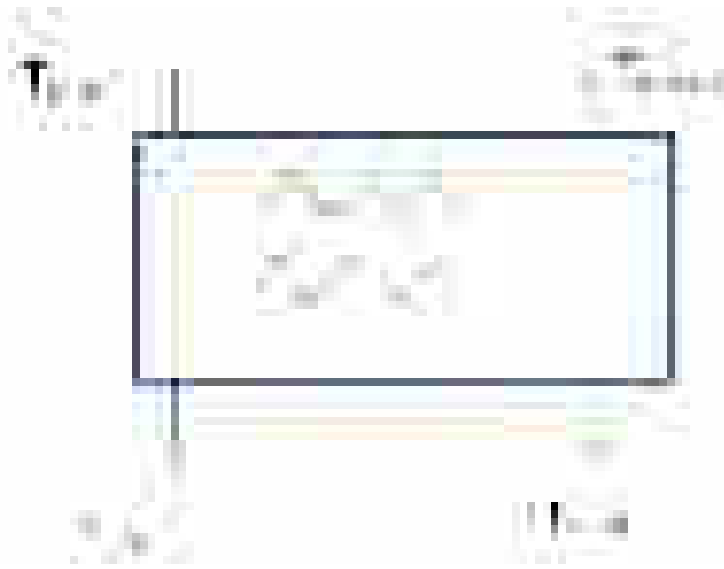

Figure 6 Oil to salt heat exchanger.

The expression relating the temperatures of the HTF and molten salt is shown below (2).

$$T_{out,st} = T_{in,st} + \eta_{hx} (T_{out,HTF} - T_{in,HTF}) \quad (2)$$

The energy storage expressionfor molten salt storage is expressed as follows:

$U(T) = msaltCp_{,salt} (T_{out,st} - T_{in,st})$ (3)

The heat transfer relationship between HTF and TES is expressed as follows:

$m_{HTF} C_{p,HTF} (T_{out, HTF} - T_{in,HTF}) = U(T)$ - Storage System Losses - Heat Exchanger Energy Losses (4)

Figure 7 shows a simple Rankine cycle power block.

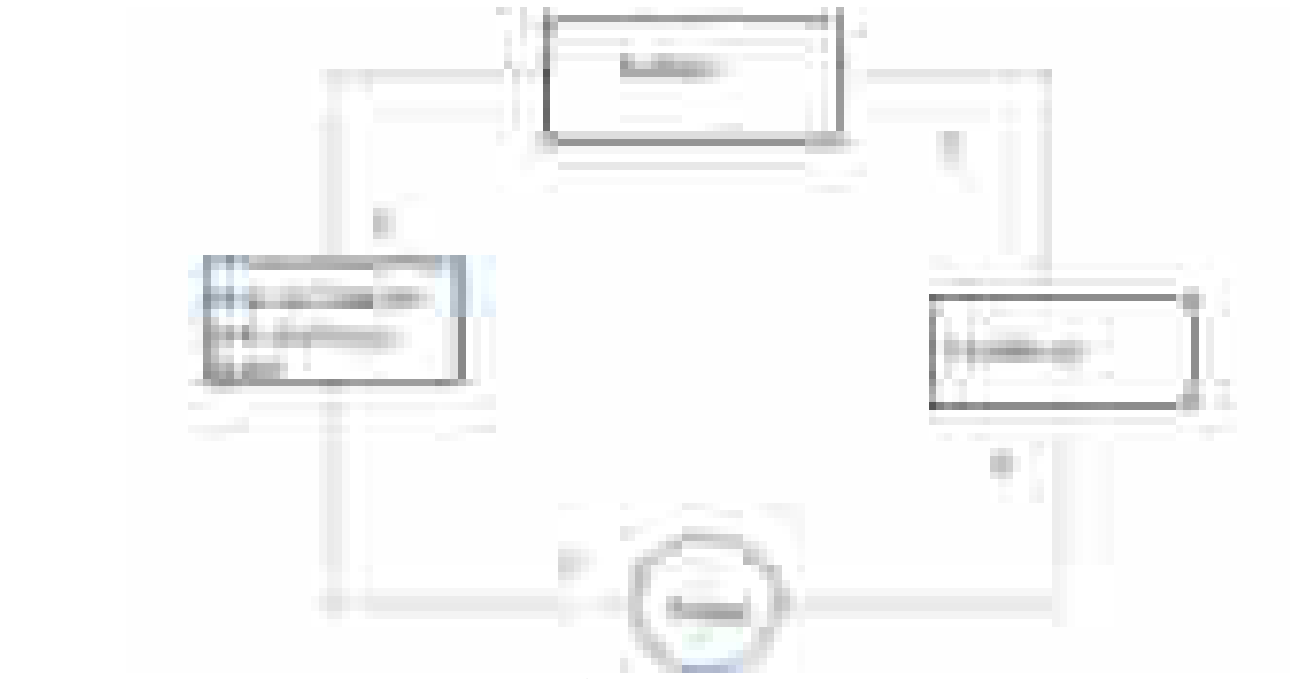

Figure 7 Power Block.

The application of the first law of thermodynamics yields the following expressions:

Heat Exchanger: $Q_{in} = h_2 - h_1$ (5)

Turbine: $W_T = h_2 - h_3$ (6)

Condenser: $Q_{out} = h_4 - h_3$ (7)

Pump: $W_P = h_1 - h_4$ (8)

$\eta_{th} = [W_T + W_P] / Q_{in}$ (9)

The expressions for the energy with and without storage are expressed as follows:

$E_{out,ws}$ = [U(T) - Storage System Losses - HeatExchanger Energy Losses] η_{th} (10)

$E_{out,ns} = [U_{HTF}(T)$ - Heat Exchanger Energy Losses]η_{th} (11)

where by:

$U_{HTF}(T) = m_{HTF} C_{p,HTF} (T_{out, HTF} - T_{in,HTF})$ (12)

In essence, the output energy is the product of thermal energy and plant efficiency. It is important to note that the plant efficiency is the same in the cases with and without storage. The round trip efficiency is expressed as follows:

$\eta = E_{out,ws} / E_{out,ns}$ = [U(T) - Storage System Losses - Heat Exchanger Energy Losses] / [U_{HTF}(T) - Heat Exchanger Energy Losses] (13)

Molten salt storage system losses estimation methods are discussed in the literature [8-10]. Figure 8 depicts the losses in a molten salt tank [1].

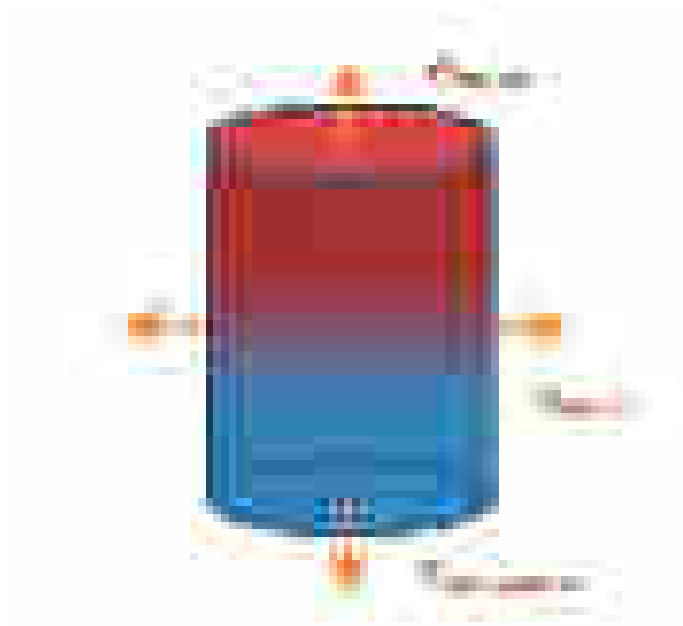

Figure 8 Molten salt tank losses [1].

The tank losses are expressed as follows:

$Qdot_{cond,loss} + Qdot_{top,loss} + \int_0^L ph\ (Ttank(x) - Tenv)dx = UoverallAref(Tm - Tamb)$ (14)

The round trip efficiency can be expressed as follows:

$$\eta = \frac{msaltCp,salt\ (Tout,st - Tin,st)\{2(1-\eta hx)\} - \int_{to}^{tf} Qdotloss\ dt}{mHTF\ Cp,HTF\ (Tout,\ HTF - Tin,HTF)(1-\eta hx)} \quad (15)$$

The round trip efficiency expressed in (15) provides a direct comparison to electrical storage technologies given the ratio is based on electrical energy, as opposed to TES performance efficiencies defined in literature and expressed in (16) and (17).

$\eta_{TES,I} = T_{hot} - T_{cold} / T_H - T_{cold}$ (16)

$\eta_{TES,II} = |\Delta G_d / \Delta G_c|$ (17)

The other metric that is important for comparing TES to other electrical energy storage technologies is the LCOE and is expressed in (18).

$$LCOE[\$/MWh_e] = \frac{IC*FCR+Fuel\ cost+O\&M\ cost}{Net\ electric\ output} \quad (18)$$

2.2 Exergy Analysis

The fundamentals of exergy analysis have been discussed [12-19]. The exergy change of the storage is expressed in (19). The exergy analysis was carried out in order to take into account the loss of available work owing to temperature loss of the storage medium. The reference temperature is taken to be the ambient temperature in this analysis. Equations (24-27) are derived using a linear form of the specific heat capacity.

$\Delta G = \Delta H - T_{amb} \Delta S$ (19)

where by:

$$\Delta H_c = \int_{Tref}^{Thot} Cp(T)\, dT \quad (20)$$

$$\Delta H_d = \int_{Tref}^{Tcold} Cp(T)\, dT \quad (21)$$

$$\Delta S_c = \int_{Tref}^{Thot} \frac{Cp(T)}{T}\, dT \quad (22)$$

$$\Delta S_d = \int_{Tref}^{Tcold} \frac{Cp(T)}{T}\, dT \quad (23)$$

$$\Delta H_c = c(Thot - Tref) + \frac{d}{2}(Thot^2 - Tref^2) \quad (24)$$

$$\Delta S_c = c \ln\frac{Thot}{Tref} + d(Thot - Tref) \quad (25)$$

$$\Delta H_d = c(Tcold - Tref) + \frac{d}{2}(Tcold^2 - Tref^2) \quad (26)$$

$$\Delta S_d = c \ln\frac{Tcold}{Tref} + d(Tcold - Tref) \quad (27)$$

The specific heat capacities of the HTF and molten salt were assumed to be linear and are expressed in (28) and (29) respectively.

$C_{P,HTF}(T) = 0.002414\ T(^0C) + 1.498$ (kJ/kgK) (28)

$C_p(T) = 1443 + 0.172\ T(^0C)$ (J/kgK) (29)

The heat exchanger exergy loss is expressed in (30).

$EX_{Loss,HX} = \int_{to}^{t} mdotf\,[\int_{Ti}^{To} Cp(T)dT - Tamb \int_{Ti}^{To} \frac{Cp(T)}{T}\,dT]\,dt$ (31)

3. Results and Discussion

The round trip efficiency and LCOE were estimated with expressions (15) and (18) using Andasol 3 data and are tabulated in Table 2. Andasol 3 is a $50MW_e$ parabolic trough plant with 7.5 hours of molten salt storage in Spain.

Table 2 Andasol 3 data used for estimation of round trip efficiency and LCOE.

Molten salt tank losses	2.5%
Heat exchanger losses	10%
Temperature hot tank	386^0C
Temperature cold tank	296^0C
HTF inlet temperature	293^0C
HTF outlet temperature	393^0C
Molten salt energy	125 MW
HTF energy	125 MW
Energy output with storage	97 MW
Energy output without storage	112.5 MW
Round trip efficiency	86%
Total project cost	400 million dollars
Annual O&M cost	1.6 million dollars
Net electric output per annum	200 GWh
LCOE	216 $/MWh$_e$

Table 3 shows the exergy analysis results using Andasol 3 data.

Table 3 Exergy analysis results.

ΔG_c	70137 J/kg
ΔG_d	-1473 J/kg
Exergy destruction/loss	2.1%
Exergy efficiency	98%
Heat exchanger exergy loss	11%

Exergy destruction is the lost available work, which is proportional to entropy generation, and as seen in Table 3, the storage exergy destruction is relatively small. This result indicates that exergydestruction in a CSP plant with storage materializes in the power block, where it lowers the cycle efficiency. Therefore, the round trip efficiency of molten salt storage systems can be formulated using energy analysis only.

The LCOE of other storage technologies are shown in Table 4.

Table 4 LCOE of other storage technologies – 50MW, 300 MWh [22].

Technology	**LCOE[$/MWh$_e$]**
CAES	275
Sodium sulphur	350
Advanced lead acid T1	625
Advanced lead acid T2	325
Zinc bromine	288
Vanadium redox	525

Table 5 shows the estimated LCOE and cost breakdown of 50 MW vanadium redox and sodium sulphur batteries with 6 hours of storage.

Table 5 LCOE cost breakdown of vanadium redox and sodium sulphur batteries [23].

Technology	**Energy Discharged per Year (MWh)**	**Investment Cost ($)**	**Fixed O&M Cost ($/kW-yr)**	**Variable O&M Cost ($/kWh)**	**Battery Replacement. Cost ($/kW)**	**Total O&M Cost ($10^6$$)**	**LCOE ($/MWh)**
Vanadium redox	109,500	186,703,160	4.5	0.0005	746	37.4	519
Sodium sulphur	109,500	153,530,750	4.5	0.0005	450	22.6	351

The estimated LCOE values of vanadium redox and sodium sulphur batteries in Table 5 are in close agreement with the corresponding values in Table 4.Tables 6 and 7 shows the cost trajectories of parabolic trough systems and solar tower systems respectively. In essence, the usage of molten salt both as a heat transfer fluid (HTF) and storage in parabolic trough CSP plants yields lower LCOE and higher efficiency, which makes it cost competitive to solar tower systems.

Table 6 Current and future costs of parabolic trough systems [11].

	2010	2010	2015	2015	2020
Design Inputs:					
Turbine (MW_e) gross/net	111/100	110/100	280/250	110/100	280/250
HTF	Syn. Oil	Syn. Oil	Syn. Oil	Salt	Salt
Solar Field Temperature (^{0}C)	391	391	391	450	500
Solar Multiple	1.3	2.0	2.0	2.0	2.8
Thermal	0	6	6	6	12

Storage Hours					
Cost and Performance Inputs:					
System Availability	94%	94%	96%	96%	96%
Turbine efficiency	0.377(wet)	0.377(wet)	0.356(dry)	0.379(dry)	0.397(dry)
Collector Reflectance	0.935	0.935	0.95	0.95	0.95
Solar Field ($/m^2)	295	295	245	245	190
HTF System ($/m^2)	90	90	90	50	50
Thermal Storage ($/kWh-t)	-	80	80	50	25
Power Block($/kW$_e$ - gross)	940	940	875	1140	875
O&M ($/kW-yr)	70	70	60	60	45
Cost and Performance Outputs:					
Capacity Factor	26%	41%	43%	43%	60%
Installed Cost ($/W)	4.6	8	7.9	6.6	6.5
LCOE (cents/kWh, real)	17.3	17.9	16.5	14.2	9.9

Table 7 Current and future costs of tower systems [11].

	2015	2020	2025
Design Inputs:			
Turbine (MW$_e$) gross/net	111/100	111/100	220/200
Solar Field Temperature (^{0}C)	565	565	650
Solar Multiple	1.8	2.6	2.8
Thermal Storage Hours	6	12	12
Cost and Performance Inputs:			

System Availability	91%	94%	96%
Turbine efficiency	0.416(dry)	0.416(dry)	0.47(dry)
Collector Reflectance	0.95	0.95	0.95
Solar Field ($/m^2)	200	143	120
Tower/Receiver (kW_t$)	200	200	170
Thermal Storage ($/kWh-t)	30	20	20
Power Block($/kW$_e$ - gross)	1140	1140	975
O&M ($/kW-yr)	65	50	50
Cost and Performance Outputs:			
Capacity Factor	43%	60%	65%
Installed Cost ($/W)	6.3	7.3	5.9
LCOE (cents/kWh, real)	13.7	10.9	9.4

Parabolic trough CSP plants with molten salt storage have the least LCOE compared to vanadium redox batteries, sodium sulphur batteries, and compressed air energy storage. The estimated round trip efficiency of molten salt storage compares well with the round trip efficiencies of compressed air energy storage, vanadium redox, and sodium sulphur batteries.

4. Conclusion

The estimated round trip efficiency of 86% compares well with the first law efficiency measure of TES which ranges from 93-99%. The estimated LCOE of parabolic troughs with thermal energy storage is the lowest compared tocompressed air energy storage, vanadium redox, and sodium sulphur batteries. The use of molten salt both as an HTF and storage in parabolic trough plants will lower the LCOE to a point of making it cost competitive with solar towers.Therefore, grid scale CSP plants with thermal energy storageis cost efficient than large scale solar photovoltaic plants with battery storage.]

The exergy destruction of molten salt storage was estimated to be about 2.1%. Therefore,molten salt storage systems have both high energy and exergy efficiency. The storage exergy efficiency was estimated to be about 98% using the second law efficiency formulation.

The TES roadmap should entail in its embodiment the technological readiness levels of thermal energy storage technologies; legal and technological framework readiness; breakthrough technologies in high temperature thermal energy storage; favourable electricity tariffs; envision needs for future energy systems complimented with a rolling-plan vision for the year 2050 deployment.

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INTENSITY OF LANDSLIPS IN MOUNTAIN GEOSYSTEMS OF AZERBAIJAN AND ITS ESTIMATION

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Abstract: *Intensive development of buildings in mountainous areas makes necessary to estimate the geodynamic risks caused by active dangerous endogenic and exogenous geomorphological processes. Active landslip events are bearing threat particularly in regard to the activity of infrastructural and tourism facilities, and their emergence leads to gross material and moral losses.*

Landslips in Azerbaijan are emerging almost in all vertical belts, and more typical for the middle mountainous belt. On the southern slope of the Major Caucasian Ridge, namely in the areas of basins of Mazimchay and Goychay rivers, landslips typically emerge at 1300-3000 meters of elevation. At high mountainous belt of the southern slope of the Greater Caucasus, landslips are observable near origins of Shinchay River. Tectonic breakings play major influential role in development of landslip processes. Landslips are observed also on northern and southern slopes of the Lateral ridge, southern slopes of the Main Caucasian ridge, near origins of the rivers of Gusarchay, Gudialchay, Velvelechay, as well as in areas of higher flows of the rivers of Garachay and Jimichay.

Landslips are widely developed in the territory of inclined Gusar plain where they are observable both in friable and in radical deposits, and are characteristic basically for slopes of valleys. Their spatial development is connected with tertiary surface clayey deposits in the river basins of Velvelechay, Gudialchay, Garachay, Aghchay, Jagajugchay, etc.

In the Lesser Caucasus, landslip processes are developing on the integumentary loamy deposits which have the big capacities (in river basins of Hasansu, Terterchay, Hakari, Paraghachay etc; the intermountain depressions of Bashkand-Dastafur, Khachbulag, etc.). At upper flows of Nakhchivanchay River, the landslips are widely developed in the areas of effusive layer, and dated basically for the edge lava covers.

In the area of Talish Mountains, the landslips basically occur in low mountain belt (in condition of sufficiently higher atmospheric precipitation and availability of clay deposits). Landslips are widely observed in the Yardimli depressive area, and longitudinally stretched at the valley of Lankaranchay as well as the north-eastern slopes of Burovar Ridge).

Key words: landslip sheet, flow, ecological risk

Introduction: Azerbaijan is situated in geodynamically active zone. Its territory is characterized by high possibility of development of dangerous endogenous and exogeomorphological processes.

The term «ecological risk» in nature management is connected with probability of occurrence of processes unfavorable for surrounding natural environment and population due to unwise economic activities. It also includes probability of occurrence of natural destructive processes (earthquakes, avalanches, landslides, floods, landslips, flooding, etc.) and those of anthropogenic character. Environmental security is based on enfeebling or preventing of risks. In our opinion, geographical (ecological, geomorphological, landscape, etc.) forecast is the most effective method of prevention or minimization of risk in nature use.

It is known that contemporary dangerous geomorphodynamic processes are developed in almost all Alpine-type mountainous areas. Endogeomorphological and exogeomorphological processes in the mountainous regions of Azerbaijan occur basically due to the intensive neotectonic and differentiated contemporary tectonic movement characteristic for the Alp-Himalaya orogenic belts, as well as such factors as peculiarities of morphostructural compositions (evidently seeable longitudinal and transverse zoning of

morphostructures), climate, surface stream etc. Indirect but rather considerable impact on intensity of development or stabilization of processes is made by vegetation, its diverse composition and coverage extent as well. The lithological factor plays influential role, too. Anthropogenic processes have double effect: the stabilizing role at local scale (for example, afforestation on slopes of mountains); and much more destabilizing due to mastering of regions by humans.

The dangerous gravitational processes observed in all higher parts of Azerbaijan's mountainous relief include landslips, collapses and taluses.

High ridges, deep valleys, modern tectonic mobility, frequent earthquakes are the features of the Greater and Lesser Caucasus. They entail great potential for gravitational displacement of large masses downwards on slopes. The number of ancient landslips is higher as well.

Landslips are widely developed in the territory of inclined Gusar plain where they are observable both in friable and in radical deposits, and are characteristic basically for slopes of valleys. Their spatial development is connected with tertiary surface clayey deposits in the river basins of Velvelechay, Gudialchay, Garachay, Aghchay, Jagajugchay, etc.

The basic text: This work is done basing on multi-year geomorphological and landscape mountain researches on regions of Azerbaijan. Landslip landscapes are investigated in detail through application and use of large-scale charts, data of space photographing (SP) and photos made from the airspace, and also with compiling up of geomorphological and landscape maps. For compiling of map-scheme of the landslip perilousness of Azerbaijan's territory we are used results indication-geomorphological interpretation of Space Photoes, and also the basins method of researches. As a result with the account lithologic features of territory, biases and expositions of slopes, and also water security of rocks the territories amazed with landslips or potentially having potential possibilities for development of landslips are revealed on a method of analogy.

We identified territories where the most intense ecolandscape geosystems with risk of occurrence of landslips makes up 65-70% of the overall area. Such dangerous zones include the medium mountainous and low mountainous zones of South-eastern Caucasus, as well as river basins of Velvelechay, Girdimanchay, Gilgilchay, Atachay, Pirsaatchay and others. In the meantime, intensive deforestation is characteristic for the middle mountain zone of north-eastern slope of the Greater Caucasus, as well as the north-eastern slope of Lesser Caucasus and also Talish Mountains due to human factor. This process is also responsible for the activation of landslips. In order to determine the grade of development of contemporary dangerous geomorphodynamic processes as well as their impact on the population and economic infrastructure in the mountainous regions of Azerbaijan, the classes of environmental hazard were identified by us.

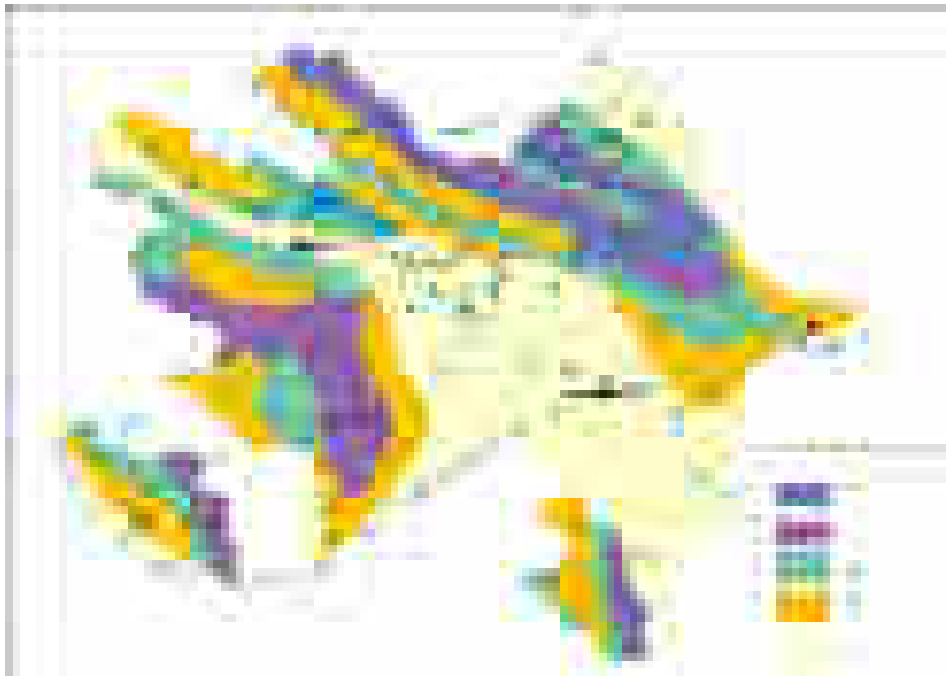

Fig. 1. Map-scheme of the landslip perilousness of Azerbaijan's territory

Legend

1. Highly dangerous territories with very active development of landslip processes (development of landslips on 65-70 % of territory is possible) - V points

2. Intense territories with active development landslip processes (development of landslips on 50-65 % of territory is possible) - IV points

3. Medium dangerous territories with intensive development of landslips processes (development of landslips on 30-50 % of territory is possible) - III points

4. Territories with rather weak development of landslip processes - of II points

5. Territories where landslip processes are not observed - I point

The Azerbaijan part of the Greater Caucasus occupies 17680 км2 of territory, and is known as a region of landslip processes. From the late 20th century to the early 21th century, the landslip displacements were activated in the cities of Shamakhi, Ismayilli, Gabala, Gusar and others. Thus, the construction of tourism and recreational facilities, highways, roads, channels, as well as the process of deforestation repeatedly resulted in relevant motions that in some cases had catastrophic character, in particular on the north-eastern slope of the Greater Caucasus (Fig. 1). The widespread horst-synclinal plateau with abrupt slopes creates favorable conditions for the development of slide processes that strongly complicate the geodynamic situation in the area of Greater Caucasus. Landslips and stream hearths are responsible for the reduction of area of mountain meadows and the enlargement of bare, strongly degraded areas which are potentially dangerous in terms of geodynamic processes. Large landslip streams are typical for the slopes on the horst-synclinal plateaus like Afurja, Khizi, Budug, Gizilgaya, and Girdagh, etc. Landslips are observed in both wetlands and areas of arid climate, and may harm the economy of this region, including such areas as basins of the river Katehchay, as well as the left slope of the river valleys of Kurmukhchay, Kishchay, Shinchay, Mukhahchay and Katekhchay rivers. Landslips of rocks are observable at the foot of the right slope of the Kurmuhchay valley. The surface of these landslip rocks is inclined to the south. The landslip sheets are evidently seen at their border zone from the east, the north and the west. The more evident of them are developed along the gravitational and

neotectonical cracks. The landslip blocks are the sources of threat for nearby settlements. On enfeebled slope deposits, especially on their bottom parts, the secondary landslips have occurred.

In the high and middle elevations of the mountains, widespread landslip masses along rivers are consisting of talus materials. Suddenly emerged landslips are spread on the left slopes of the valleys of Kurmukhchay and Kishchay rivers, or in ancient alluvial and proluvial deposits.

Nival areas, high mountains, and partly middle-mountain zones serve as arena for collapses and mobile taluses which contribute to the creation of mud flows. They may fall down in areas of high slope relief, and are collected in channels of water streams. Landslips and talus processes are frequently observed at the upper flows of Mukhakhchay, Kurmukhchay, Shinchay, Kishchay, Gusarchay, Velvelechay, Gudialchay and other rivers (1,2,5).

As is shown above, natural destructive events such as avalanches, landslips and collapses entail intense ecological situation in the Greater Caucasus. The activation of adverse natural processes as well as landslips in condition of increasing anthropogenic influence necessitates the detailed research and regular monitoring. Research on occurrence and development of landslips must be carried out in order to define the characterization of occurrence and further development of this process. Hence, the account of these circumstances must serve as a basis for the concept of management of ecological risk.

Fig. 2. A landslip in Alekseyevka village of Guba region (one person was lost. The photo taken on September 24, 2012)

Besides this, landslips in Azerbaijan are exposed to the influence of azonal and regional features of the nature. Regional features of landslip landscapes depend on history of development of territory in the neogen-anthropogenic period, including the contemporary stage. It gives opportunity to track litogenic bases of formation of regional landslips landscapes.

In the north - eastern slope of the Greater Caucasus, landslip landscapes are widely developed in low- and middle mountainous areas (basins of the rivers Tairjalchay, Ukorchay, Gusarchay, Gudialchay, Gilgilchay, Atachay, Tughchay, Girdimanchay, etc.). They are being influenced by neotectonic activity of breaking zones and their crossings, and also higher atmospheric precipitation on the slopes of northern

exposition (800-1000 mm in basin of Velvelchay River). The higher concentration of landslips in the area is connected with the existence of large breaks, clay deposits of Maikop retinue, as well as seismicity and a higher amount of atmospheric precipitation. Moreover, the development of landslip landscapes is related with the interval of hypsometric levels from 400-500 meters to 2500-2800 meters, and also the coastal strip of the Caspian Sea.

Landslips of the Greater Caucasus typically change morphology of slopes, and are responsible for the emergence of the new kinds of landscapes sharply different from initial ones. The occurrence of landslip landscapes and various natural boundaries and facies depends on such factors as size of landslip, age and litological structure of involved rocks, steepness of slopes and anthropogenic activity. We consider that dynamism of landslip landscapes must be taken into consideration in the research area. This concerns particularly the gradual reduction in weight of landslip masses which are in different stages of the development at different hypsometrical extent.

In terms of morphology and scale formations, the landslip landscapes within the territory of Azerbaijan are subdivided into the sheet, landslips-streams and landslip collapses (1,3,4).

The landslip sheets are spread on the slopes of mountains and plateaus as well as along with boards of river valleys, consequently becoming much more in size. Their wavy surface has landslip terraces and wide cracks stretched horizontally. The landslip sheets are widely developed in valleys of the rivers of Tahirjalchay (near Sudur village), Ukorchay (Adjahur village), Gusarchay (Susay village), Gudialchay (Gachrash, Gimil, Giriz and other villages), Garachay, Velvelechay (Jimi, Afurja, Tengialti), etc.

There are three basic sites sharply differing from each other in places of these streams: an amphitheatre, a transit site, and a cone-form relief created by rivers. These ones are widespread along Lateral range, Major Caucasus and Nialdagh ridge, as well as the depressions of Rustov, Yerfi, Khaltan, Gilgilchay, and also the Caspian Sea(2,5,6,).

Landslip streams are developed in valleys of the rivers of Samur, Gusarchay, Gudialchay, Garachay, namely along their higher and medium flows where mountainous forests and subalpine landscapes are widespread. In valleys of the rivers of Velvelechay, Atachay and Tughchay, the availability of ancient and contemporary landslip streams results in catastrophic consequences (near Atuch, Yerfi, Garabulag, etc). For example, the larger and most dangerous landslip stream is located on the right bank of Velvelechay River, where it makes up 5 km in length and 2 km in width (cone relief), whereas the amphitheatre reaches 0,8-1 km. The largest contemporary landslip stream is called Himran having length of 4,5 km. It emerged in 1946 and sometimes became more active (1947, 1948, 1950, 1953, 1954, 1956, 1963, 1971, 1984, 1990 and other years). The researches carried out by us show that the mentioned landslip stream becomes more active annually after snow-melting and strong rains. Length of relevant amphitheatre exceeds 1 km, while width of the cone is 2-2,2 km, and the average bias makes up 15-20°. The Himran landslip stream has blocked riverbed of Girdymanchay and caused arising of lake.

The main landscape-forming signs of landslips and collapses are the collapse materials (fragments of sandstone, limestone, clay, etc). Landslip landscapes are widespread around the Shahdag peak, the Gizilgaya plateau, and also in the bottoms of valleys of the rivers of Shabranchay, Gilgilchay, Atachay, Tughchay and others. Here and also near the coast of the Caspian Sea, the main landscape-forming rock is clay which may be washed off in condition of heavy rains, and do not entail soil cover and vegetation.

The landslip sheets are most typical for basins of the rivers Gusarchay and Gudialchay which are connected with the Lateral and Nialdag ridges. Landslip streams may meet in all river basins of the north-eastern slope, whereas landslip collapses are widely developed in the Shahdag-Gizilgaiya highland area and the Nialdag ridge, as well as at medium and lower flows of the rivers of Aghchay, Garachay, Jagajugchay, Velvelechay, Shabranchay and Gilgilchay.

The Lesser Caucasus has very complicated morphotectonic structure and it is characterized by wide development of tectonic mantles, olistostrome, ophiolites, magmatic and mud volcanism and also by frequent change of the direction of strike of large morphological structures, activity of seismotectonic and modern

tectonic processes, sharp differentiation of exogenic processes, etc. Nival-glacial and gravitational processes (avalanches, landslips, caving, trough valley, kars, circus-form reliefs) occur in highland area on the background of intensive neotectonic uplifts. The elevation of landslip areas ranges from 1000 to 3000 m. The highest atmospheric precipitation (600-900 mm) is observed here. Landslips and mud flows are widely spread in the areas of large basins of Khoshbulag, Dastafyur and Novosaratovsk rivers. They are especially well-traced in the river terraces of valleys of rivers of Zeyamchay, Ganjachay, Shamkirchay, Kuryakchay (Fig. 8) and their tributaries. Dastafur basin and adjacent Khoshbulag basin are abundant in large mud flows, spread on their southern sides. Numerous mudflows are observed in the area of Goygol Lake and at the large benches near Kapaz Mountain as well as the higher stream of Buzlukh River. A large technogenic landslip (520 m in width and 5-30 m in height) with over 4 mln. m^3 of landslip material has emerged in the southern part of Dashkasan peak due to unwise extraction of waste rock. Lateral speed of the movement of the landslip were 0,36 cm/day since 1990 due to freezing of soil in winter and melting of ice in spring, as well as snow- melting and seismic movements.

Fig. 3. Active landslip in Dozulu village, Goygol area (August 25, 2006)

Landslips are spread particularly in the higher streams of Ganjachay and Shamkirchay rivers as well as the adjacent areas. They significantly reduce the area of mountain meadows. Therefore, the exposed, hardly degraded and potentially geodynamically dangerous areas are expanding in this territory. Intensive deforestation in middle mountainous areas of the territory was responsible for arising of landslip displacements.

Landslips occur in the basins of Terter and Hakari rivers, too. In the central part of the Lesser Caucasus, landslips are associated with ophiolite strip. Serpentinite and serpentinitized rock that is common here is characterized by strong crushing, intensive fracturing and weak resistance against denudation. Under favorable conditions separate blocks and masses of this rock move along shear planes and tectonically slipping planes which are evidently observed on the southern slope of Murovdag ridge near the higher stream of Soyudluchay, Levchay, Bulanigsu and other rivers. Caving and talus material are widely spread in the area of Girkhgiz, Sari Baba, Beyuk Kirs, Ziyarat mountains, etc (2,3,7).

The mountain part of Talish Mountains is characterized by numerous transverse erosional ridges, stretching over many kilometers in the form of narrow water-separating relief forms. They are common mostly

in the basin of Tangarud, Astarachay and other rivers where the degree of erosion dissection is highest. Most intensive dissections are typical for the Talish and Peshtasar ridges. It is connected with the process of intense physical weathering as a result of the prevalence of arid condition.

Landslips, frequently forming circuses in the riverheads are quite common in the mountain part of the Talish region. The development of contemporary exogenic relief-creating processes depends on the elevation of the relief, the recent and contemporary tectonic movements, exposure of slopes, climate condition and other factors.

In Talish, landslips are characteristic for lower mountain belts, where relatively higher atmospheric precipitation is observable and clay rocks are spread.

Landslips are confined to slopes with thick layer of diluvial or clayey sediments. Landslips are mostly developed in the area of Yardimli depression where they are confined to the slopes, composed by Maikop sandstone and shale sediments that do not have forest cover. Landslips within the Yardimli depression are observable on slopes of almost all river valleys. Landslips here are destroying slopes, transforming them into unsuitable land. Meanwhile, it may be responsible for break of transport communication.

The conclusion: The above-remarked data and the compilation of map-scheme give a basis to conclude the study work as follows:

1. Special attention in studying of landslips should be given to landscape-creating role of the components that influence the development and formation of landslip landscape, namely lithological structure of rocks, a steepness of slopes, an atmospheric precipitation, hydrological conditions, soil and vegetation cover;
2. Identification of more efficient way of ecological optimization is needed that will not destroy the mechanism of a dynamic constancy of the system. This will allow prepare recommendations on decrease of ecological risks in nature management.

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A Historical study of Economic Life of Women from 13th century AD to the end of the 15th Century

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Abstract

In this study an attempt is made to study the Economic life of women from about the thirteenth century A. D. to the end of fifteenth century A. D. This period is generally known as the medieval period of Sri Lanka which is after the Magha's invasion. In order to determine the place of women in society, it is necessary to study the attitudes of men towards women and particularly the services rendered by women in their various roles as mothers, wives, sisters etc with special reference to their involvement in Economic, political, social and religious affairs. Any serious attempt to study these aspects is beset with certain difficulties, which must be borne in mind from the beginning. On the one hand, the chronicles provide comparatively little information on those activities of women to which the student of social history should attach importance. On the other hand, even the information of chronicle that we find is limited to women belonging to courts circles or to the nobility. The role of ordinary women in society would certainly deserve great attention, because some of our literary sources reveal this aspect. In addition to that, there are a number of epigraphic records which contain much information about position of women.

The research is mainly based on primary sources. Wherever necessary material will also be obtained from limited secondary sources on the social history.

Key words: Economic life of women, attitudes, information of chronicle, epigraphic records, Prostitution

1.1 Introduction

Economic life of human beings depends on pattern of occupations in the present time as well as in the past. Therefore, it is an undeniable fact that males and females had an equal responsibility with respect to agriculture. Because the production of a country is mainly based on the employment of people, both male and female have to participate in the economic development of the country.

The Sri Lankan woman carried out the duty of a housewife and mother while actively assisting the economic functions of the husband. The function of a woman was multiple in the self-sufficient society of ancient Sri Lanka. Labor of women in any society is generally connected with various issues of production and exchange. But it is not easy to gather to what employment of women had and what function it performed.

Division of social labor is based on social structure and how it has affected the labor of women. Basically, ancient Sri Lankan society was an agricultural society. Agricultural, economic and social organizations of Sri Lanka had change underdifferent forms through the centuries the sixth BC to the the sixteenth. One major factor for these changes is the transformation of a society of primary agricultural society in early period which was based on water agriculture which was supported by a developed irrigational network in the fourth century AC. There was deference between labor requirements of a society of primitive agriculture and labor requirements of a society of extended agriculture. Therefore, labor problem in general and women labor problem in particular emerged from the dynamics of the organization of agricultural production.

There are several factors in the employment of any group of society in any historical age. Pattern of necessities, nature of resources, and complexity of society and nature of the relevant group in the social structure of in a society could be mentioned as those factors. Ancient Sri Lanka is a country with a

magnificent culture which was influenced by Buddhism. Therefore, simple strategies were connected with employment. Pattern of life was very simple and it was composed of limited necessities. Due to the utilizing natural resources, people were sufficiently provided from the paddy land and jungle areas. For instance, they made all house instruments by the clay or wood from the forest.

Because there was a patriarchal society and limited necessities were found by her from the surrounding, women had to engage in working at home, home gardens, chena and largely in paddy fields. According to the economic condition of ancient Sri Lanka, a woman gave her labor for the income in primary or in secondary ways. Because women had to engage mainly in preparing and cooking food, subsidiary service was given in the paddy field. Accordingly, men used the knife, mamaty and axe while women were using items connected with houses. Assistance in the paddy field, transportation of crops and store keeping, preparing food from those crops and cooking of various foods from prepared crops were the main functions of house life done by the village women.

Saddharmaratnāvali and *Pansiyapanas Jātaka* written in the period of Dambadeni and Kurunegala respectively, describe the way of paddy industry in Sri Lanka. Ancient Sri Lankan people engaged in farming the whole year.(*Saddharmaratnāvali***,** 1985: 221).

Women may engage in this paddy farming as the assistants of the farmers. This description reveals that ancient Sinhala people had an excellent experience in systematic agriculture.

1.2 Paddy farming and women

Women participated in activities of the paddy field efficiently and enthusiastically. Therefore, it cannot be said that the basic feature of women was participating only in some activities in the paddy cultivation. It was dependent on social class and economic condition of people. Some Queens have helped to develop paddy farming by restoring some tanks according to some inscriptions. An example is the Batalagoḍa väva inscription. The record dated the fifth year of Queen Kalyāṇavatī who ascended the throne in 1202 AC. The main object of the inscription is to record the repairs effected to the Batalagoḍa väva. It is mentioned as follows.

> Madhya dēsa in the kingdom of Māyā, at the time this… reservoir was lying unused, {its embankment} being breached in three places [and its] canals and sluice being destroyed…repaired the canals and the sluice and made them to be of used. Having seeing that not many fields and gardens were flourishing, as there was no second sluice even in former times, he, by his own judgment, examine sites[fit] for sluices, and having found a suitable site [for a sluice] , he constructed there a sluice called, after his own name, the Adhikāra sluice and brought under cultivation… from the lower embankment. (*Epigraphia Zeylanica.*, Vol. IV, 74-82).

According to the description of this inscription, a minister has supported the implementation of the tanks' restoration. This may have been continued under the guidance of Queen Kalyāṇavatī.

Vap ceremony was a very important festival linked to paddy farming. Due to the raining of Vap (October) month, seeds grow very well. Therefore, growing of paddy started in the *Vap* month. All males and females participated in this festival. *Saddharmālaṃkāra* mentions that women participated in the *Vap* festival like men, dividing their labor. (*Saddharmālamkāra,*1954: 707). According to the description, many people were engaged in paddy farming. People plough in the paddy fields wearing many ornaments and they decorated white oxen with the jewellery. Women of the home dressed well and they planted the paddy seeds. Therefore, we can come to the conclusion that women had participated in the paddy farming in many ways, even though they had much work in their homes.

There are many activities in the paddy field after sowing the paddy seeds in the field until paddy leaves are brought to the *kamata*. Harvesting paddy is a very important activity after growing the seeds. When farmers put paddy into the field, sometimes, it may be collected at one place. Therefore, small paddy plants should be taken and be planted at another place of the same paddy field. This was especially done by women.

(Disanayaka, 1985: 557). While these activities were being done, women were engaged to remove weeds from the paddy field. Because there were no pesticides in the past as in the present time, weeds had to be removed manually. Mothers with small children were brought to the paddy field, and they assisted their husbands in farming. *Nandimitra Vastuwa* of *Saddarmālaṃkāra*confirms this. (*Saddharmālaṃkāra***,** 1954: 504).

Regarding protection of the paddy field, it was a main responsibility of women and it had to be done in between the times of growing paddy as a daily routine.(*Pūjāvali***,** 1986: 376).The expression is mentioned in the *Pūjāvali* and it means that woman had chase birds such as parrots by screaming and running here and there in the paddy field. According to the various kinds of paddy, being grown in the field, protection of a paddy field was essential. A paddy field which grows*hīnaṭi* (a kind of paddy) should be protected for three or four months and *mā vī* should be protected for seven months from birds. (*Ibid,* 376).

During the time of medium size of harvesting, it can be realized that paddy field was protected from birds by a small girl or a young lady. Chasing of birds was a very interesting hobby. Therefore, she was engaged in that duty by singing songs. (*Saddharmālaṃkāra***,** 1954: 156-157). One Siṭāna*,* a person of great wealth, sent a girl to the paddy field to protect the paddy field and she went to it and stayed in a small hut, chased the birds by singing songs. According to the expression of *Saddharmālaṃkāra*, she enjoyed working in the paddy field. There are many interesting episodes which are related to the protection of paddy fields by singing girls in the *Vangīsa Saṇyuttaka* **(***Saṃyutta Nikāyaṭṭhakathā*, 1924: 211)and *Saddharmaratnāvali* **(***Saddharmaratnāvali*, 1985: 458).

The assistance of women in paddy and swidden cultivation was brought to male without any restrains. There is reference to very large *häl* chenas in the literature during many periods. Chena cultivation had expanded from the Polonnaruva period. Crops such as paddy, *undu* (phaseolius mungo), *mā̄* (Vigna cylindraika), *mun*(Phaseolus aureus), *menēri* (Paspalam scrobiculatum), *aba* (Brassica juncea), *duru* (Cuminum cuminum), and taṇa (Setaria italica) were grown in the chenas. Kangu, a kind of crop was grown from the Anuradhapura period. By the time of Gampola and Kotte ages, *Sandēsa* poems mention the growing of *Häl* paddy, protecting of those paddy fields was a duty of women. There is also reference to female farmers. Sandēśa poems such as *Parevi, Sävul*(*Sävul Sandēśa*, 1969: v. 127), *Girā,* (*GirāSandēśa*, 1920: v. 74), *Sälaḷihiṇi*, (*SälaḷihiṇiSandēśa*, 1972: v. 37), *Kōkila* **(***KōkilaSandēśa*, 1962: v. 215), and *Tisara*(*TisaraSandēśa***,** 1991: v. 125)etc. describe the role of female farmers. For instance, Toṭagamuve Sri Rahula Thero, the author of *Parevi Sandēśa,*mentions the female farmers who were chasing the birds with some bells.(*Parevi Sandēśa,*1953: v. 111).Protection of paddy fields of *äl* and protection of cotton chena was a responsibility of female farmers.

Harvesting of paddy was a prime duty of women in the paddy production. After harvesting the paddy, women were assigned to remove the *vī bol* and *piduru*. A special feature of the ancient society was the assistance given to the father or husband in every activity of the paddy field or chena. Although there were many activities at home or home garden, a female was not reluctant to work with males. Therefore, sometimes she was honored by the husband or father.

Preparing lunch for husband, father or relatives who were engaged in the paddy field or swidden agriculture was also assigned to the women. Princesses also participated in this activity. Even though, it is not relevant to our period, Princess *Pāli* and daughter of King Suba could be mentioned as instances. Women of the rural society, who mainly did farming as the main occupation, also prepared food regularly. *Saddharmaratnāvali* describes several instances of the above mentioned fact. (*Saddharmaratnāvali*, 1985: 613, 476). Villagers lived mainly in the proximity of the tank of the village. The paddy field was located near the tank as a water resource. When the sun comes to the zenith at mid-day, women go to the paddy field with lunch (*ämbula*). It was a main characteristic of the daily life of women. Some inscriptions mention that there were three times of farming in Sri Lanka in the Anuradhapura period. (*Epigraphia Zeylanica***,** Vol. III, 1933: 177). This shows that, much work had been assigned to the women in ancient and medieval Sri Lanka.

After harvesting the paddy, the crops were transported by oxen carts or men from the paddy field to the home. Paddy was then stored by the women at home. According to *Theri Gāthā,* some women meditated at

the time of preparing paddy for food. Preparing paddy for use was a main assignment of the women in contemporary India, according to the descriptions of *Theri Gāthā*. After becoming a nun, Nun Sumangalā expressed her happiness by using words *Sumuttikē sumuttikē sādu- muttikamhi mūsalassa.*(*Theri Gāthā, Psalms of the Sisters*, 1948: 24-25). This expression gives meaning avoided by all hindrances. When there was much work at home, women could not finish it in the day time. Therefore, sometimes they may have worked in the night without sleeping.

The housewife had to engage in several duties of the paddy field, chena, home as well as the home garden. Vegetables such as cucumber, beans, *karabaṭu* (Solenum sp), *tibbaṭu* (Solenum indicum), *Vambaṭu* or brinjawl (Solenum melongena), *alu puhul*(Benincasa hispida) and *Vaṭṭakkā* or pumpkin (Cucurbita maxima) and fruits such as Mangoes, bananas were grown by the women according to some literary sources. According to these descriptions, it clearly shows that ancient Sri Lankan woman took a leading role in the activities of farming, including chena cultivation very courageously.

Commercial activities occupy an important place in the economic life in ancient Sri Lanka. It is difficult to find women engaged in commercial activities, although there are many references to merchants in literary sources and inscriptions. But by the time of Kotte period, Sandēśapoems cleary describe that men as well as women engaged in the activities of commerce in Sri Lanka. The author of *Girā Sandēśa*for example, describes the female merchants who were engaged in commercial activities without any cheating and robbing. (*Girā Sandēśa*, 1920: v.58). This depicts that women had sold the items not only in the trading shops, but also under the shade of trees. According to the *Tisara Sandēśa*written in the Gampola period, women sold commercial productions by using their loved voice. (*Tisara Sandēśa,*1991: v. 56).

The good life of women is depicted in the Sandēśa poems. There is not sufficient description about women who were engaged in commercial activities which used prices of commercial items.

1.3 Animal husbandry and women

Animal husbandry is considered as a basic component of ancient Sri Lankan economy. Both buffaloes and cattle were used to plough, press down and prepare the soil of rice fields before sowing the paddy. And cows were used milking and for propagating the animals. *Saddharmaratnāvali* describes a man taking a plough and a pair of oxen (*gongeya*) on his way to the paddy field. Taming of Cattle for paddy farming and dairy products were necessary in that time. The housewife milked from cows. *Saddharmālaṃkāra* mentions that a woman called *Tissā* who lived in Rohaṇa Janapada got milk from cows daily without neglecting. (*Saddharmālaṃkāra,*1954: 555-559). Milking cows was considered as an honorable occupation. Therefore, not only ordinary women but also daughters of ministers were engaged in milking cows. Even though it is not relevant to our period, the consort of King Saddhātissa was very clever milking cows. (*Rasavāhini*, 2001: 32-34). Both women and men used animal husbandry by giving animals to eat grass. Sandēśa poems, which were written in the period of Gampola and Kotte, refer to women who reared cattle and cows. They illustrate that it was a very common feature in the daily life of people. Not only in remote areas, but also in towns such as Moratuwa, Potupitiya, there were women who were engaged animal husbandry. (*TisaraSandēśa***,** 1991: v. 89).This shows that there were some women who were protecting buffaloes in Moratuwa. This is corroborated by the poem of *Girā Sandēśa.*It says that there were women who were protecting buffaloes in Potupitiya. (*Girā Sandēśa***,** 1920: v.73).

1.4 Cotton industry and woman

According to Uggaha Sutta of *Aṇguttara Nikāya* (*Aṇguttara Nikāya*, 1968: 58-59) a girl should have a knowledge about weaving cotton and weaving goat fur. Some Brahmi inscriptions such as Galkandegama (*Inscriptions of Ceylon*, 1970: Vol. I, No. 1145, p. 90) Hittaragama hinna (*Ibid***,** No. 1160, 92) record that there were cotton industry from early Sri Lanka. They refer to the word *Pehekara* which means cotton industry. Galkandegama inscription refers to a *pehekara* village. Donations of *kaṭhina* robes to the monks were considered an activity of special merit in Sri Lanka. Ancient records which mention the*Kaṭhina* festival,

describe the preparing *kaṭhina* robes on the day after finishing the spinning cotton and weaving clothes.*Pujāvali* and *Mahāvaṃsa* mentions activities of cotton industry were finished in one day by assembling all men and women during the period of King Parākramabāhu II (1236-1270 AC).(*Pujāvali*, 1986: 796; *Mahāvaṃsa***.**, 1992: 86: vs. 103-104) .

Not only common women but, nobles also participated in the harvesting of cotton, spinning threads, washing and dressing of *kaṭhina* robes. Some women were skilled in cotton industry. *Pujāvali* records such a woman thus: *Puḷul ral tunin tuna badā makuluhu sē itā sukshamava hū käṭīmaṭa daksha vūha.(Puḷāvali,*1986: 610). Some women have woven beautiful pillows, according to the expression of *Vaivarna kaḍakin masana lada māvulāvak of Saddharmaratnāvali*(*Saddharmaratnāvali*, 1985: 613, 78).

1.5 Culinary practices and woman

Learning of culinary practices or *sūpaśāstra* was considered an important aspect of the life of a woman. (*Saddharmaratnāvali*, 1985: 236). King Duṭṭhagāmani consented to the marriage of Sāliya and Asōka Mālā, due to Asōka Mālā's cleverness in cookery.(*Saddharmālaṃkāra,*1954: 574-575).

Preparing food was not only limited to common women. Daughters of kings and princesses were also experts in culinary skills. (*Saddharmaratnāvali*, 1985: 261).*Kiñci Saṅghā* who was the daughter of Minister Saṅghawas taught cookery by her parents. *Saddharmālaṃkāraya* mentions *Ungē demavpiyō äya sūpa Śāstrayehi abhyāsa karavā pisina sē igänvūha***.**(*Saddharmālaṃkāra,*1954: 634). Food in ancient Sri Lanka composed of many varieties. The *Mahāvaṃsa*mentions *Khādya bhōjyayen da esēma leyya peyyen da.*(*Mahāvaṃsa*, 1992: LXXXV: vs. 38).A woman was very clever in cooking in these four kinds of methods. Women who cooked very tasty and delicious food were called *madhurapācikā*. Further, *Saddharmaratnāvali* describes the red *äl* rice with peacock meat as well as milk rice without mixing water. (*Saddharmaratnāvali*, 1985: 661). Housewives cooked various kinds of dishes for eating rice. (Sannasgala, 1989: XXVI-XXXV). Women cooked all these kinds of food in the kitchen to offer to the monks. She got training in cooking and working thoroughly from childhood. The *Pūjāvali*mentions a good example of this. There was a woman who had a headache. The physician treated her with medicinal oil. When female servants put oil on her head, some oil fell on the flour. The woman advised them to preserve the oil. The doctor thought that this woman was very frugal. At that time, that woman said

Api upayana avasthāvehi mesē siyumva upayana sēk danumha. Viyadam karana avasthāvehi udāra koṭa denu sēk danumha. Bim hī giya telitten kisivekuṭa prayōjana näta.Pulunin gat telitta pahanak hō avuluwāliya häkka.Nätahot kana hō tabā gata häkka.(*Pūjāvali***,** 1986: 57).

This story reveals the cleverness in earning and spending of assets of her and the ability of working very carefully. Although this story is related to India of Buddha's day, it also reflects the social condition of women in Sri Lanka at the time of the period in which *Pūjāvali* was written.

1.6 Miscellaneous

In addition to the above mentioned roles, some women were engaged in very special duties. For example, some women were engaged in the duties of supplying of flowers and making garlands. An inscription of Queen Kalyāṇavatī (1202- 1208 AC) mentions female garland makers. *Mangul miḍiyan mālākārin prasādayen ranin satuṭu karavū* (*Epigraphia Zeylanica.***,** Vol. IV, 1933: No. 5, 259).

Sinhala literature mentions female servants who stayed in their masters' houses. The daughter of Nakula Upāsaka who had been a laborer at a home in *Māgama* (*Saddharmālaṃkāra,*1954: 578), the woman called Tissā who worked (*Ibid*, 584) homes which were owned by money lenders and the girl who swept the garbage in the house of JōtiyaSiṭāna are some examples. (*Saddharmaratnāvali*, 1985: 777). There is some evidence of villages and lands which belonged to monasteries that were cultivated by women slaves in the time of Polonnaruva and Dambadeniya. (*Mahāvaṃsa*, 1992: LXXXX: vv. 35-41). During Queen Kalyāṇavati (1202- 1208), Minister Āyasmanta donated paddy fields to the temples in Pannala and Kulavaḍana at

Väligama. An inscription of Queen Kalyāṇavatī records the expressions *Pā deniyē pän nagana gānun* and *dāmāle bälū mangul miḍiyan*. (*Epigraphia Zeylanica***,** Vol. I, 1912: 256). According to those, duties of them were filling water into pots for washing the feet and the protection of the relic house in Ruwanmeli Seya.

In addition to the information of female workers, there are some facts that could be seen on the slave system in Sri Lanka. Senarat Paranavitana has presented some facts about the slave system of Anuradhapura period. Galapāta Rock Inscription of King Parākramabāhu II (1236- 1270) in the period of Dambadeniya records the donation of slaves to the Vihāra for the purpose of performing service to the monks of the Vihāra. This was done by *Demaḷa Adhikāra Mindalanā* and his mother (*Epigraphia Zeylanica***,** Vol. IV, 1934: 203). It is mentioned as follows:

> …Mema vihārayaṭa hā mē vihārayehi väḍa hindinā vahansēvarundāṭa atpā mehe karana paritden apa anvayāgata vahalin hā ran vahalin hā mē vihārayehi mundu karanduyen randīḷā genälū… (*Ibid***,** 203-204).

And in order that they may perform services to this vihara and to their lordships [the monks] residing in the vihāra, the following [were granted] from among the slaves who hereditarily belonged to our family, the purchased slaves and those acquired by paying gold from the funds of this vihāra.

Hettiaratchi (Hettiaratchi, *Op. Cit*., 1988 210-255), Ellavala (Ellawala, 1969: 56-72) have pointed out the slave system of ancient Sri Lanka. According to Ellavala, slaves were normally employed in the capacity of domestic servants and labourers. (*Ibid*., 59). The word *dāsa* is in the Rg Veda, in the sense of the enemies of the Aryans. Thus it seems that the conqueror in those early days treated the conquered as his slaves. This was no doubt the usual practice in India even during the Post- Vedic India. According to the Vinaya, there were three categories of slaves. Those that are born in the house (*Antōjāta*), those that are bought with money (*Dhanakkhīta*), those that are captured in the war. (*Karamarānīta*).(*Mahāvagga*, 1929: 95-96). The *Nīti Nighanḍuva* names another category of slaves, those who for their livelihood or for their protection, of their own accord, agree, for a certain sum, to become slaves; who steals the property of others; or burn the house or granary of others and cause damage; the person who borrows money, is unable to pay the principal and the interest, and thus becomes the slaves of the creditor. (*Sāman dāsaviopagato*) (*Nīti Nighanḍuva*, 1994: 7). The *Manusmṛti*speaks of seven kinds of slaves: *Dhajāhrta* (those who are captured in war), *Bhaktadāsa* (those who serve in return for maintenance), *Krīta* (those who were bought), *Dātrima* (those who are received as gifts), *Paitrika* (those who are inherited from the father) and the *Danḍadāsa* (those who are made slaves by way of punishment. (Manu, VIII, 415.) According to both *Samantapāsādikā* (*Samantapāsādikā***,** Vol. V, 1000-1002.) and the *Nīti Nighanḍuva* (*Nīti Nighanḍuva,* 1994: 7) there were four kinds of slaves in Sri Lanka. Those are Antōjata, Dhanakkhīta, Karamarānīta and *Sāman dāsaviopagata.* The first category consisted of slaves who had been born and bred in the same family for generations. The second category of slaves are those purchased from their parents or their masters. The third category is those stolen from a foreign country, captives taken in war by kings, and women who, having been expelled from their families for losing their caste, have become the property of the state. The meaning of the fourth category has been presented earlier. There are numerous instances showing that *dāsas* were employed in the Buddhist temples, royal house holds, and in the noble families and other rich households. In fact, the Buddha had prohibited monks from accepting male or female *dāsas*. But, as the passing of time, due to the development of monks, properties attached to the monasteries, *dāsas* were accepted by the monks. The commentators may have tried to justify such acceptance by interpreting it to suit the injunctions of the Buddha. The *Samantapāsādikā* describes how monks became to own dāsas.

Duggata manussā saṇgham nissāya jīvissāmā ti vihare kappiyakārakā honti; bhikkhussa ñātakā vā upaṭṭhaaka vā dāsaṃ denti; attanōva assa dāso atti; sāmikā dāsaṃ denti; nissāmiko dāso hoti. (*Samantapāsādikā,*Vol. V, 1001).

'Poor people become kappiyakārakās themselves in the monastery (thinking we) shall live depending on the Saṃgha; the relatives or patrons of a bhikkhu grant a dāsa (to the Bhikkhus); one (bhikkkhu) has his own *dāsa*; masters grant a *dāsa* (to the bhikkhus); a *dāsa* who is without master be a *dāsa* to the bhikkhus.'

It becomes clear that dāsas were offered to the monasteries by kings and those dāsas were known as *ārāmikadāsas*. (*Samantapāsādikā,*Vol. V, 1001.). Hettiaratchi compared the word *ran vahalin* of the Galapāta inscription with the word Dhanakkhīta. His argument refers on the meaning i.e. 'purchased slaves'. (Hettiaratchi, *Op. Cit.,* 1988: 236). Interpreting the word *ran vahalin*, Gunawardhana also says that it records an actual instance in which slaves were purchased with gold belonging to a monastery. (Gunawardhana, 1979: 121). The slaves in Sri Lanka were treated rather as adopted dependents or faithful domestic servants than as menials like the type in the European slavery system. They were employees as guardians, and the personal attendants, of the members of the royal household and sometimes they were entrusted with secret missions of high responsibility. Therefore, it can be surmised that this mild treatment of slaves was much favoured in Sri Lanka owing to the influence of Buddhism from the 3rd century BC onwards. The absence of restrictions on female employment is noteworthy, a practice quite unacceptable in Sri Lanka today.

It is interesting that slave women are mentioned in the Galapāta Vihāra inscription by their names; Ubā who was the mother of Konta Bōganta*,* Mindi who was the sister of Konta Bōganta*,* Godāli Dēvāwho was the daughter of Mindāl Kāmiyā, Sātiyāwho was the daughter of Sigiliya,Selliyā who was the sister of Sigiliya, Kāliraka who was the daughter of Gōdāli,Suwa Gōdāliyā who was the daughter of Māniyā,SēnanKottiyā**,**her daughter Kottiyā**,**her sister Raka**,**Mindi who was the wife of Raka's brother,Sātiyā who was the mother-in-low of Tōranāthā*,* his sister Sātiyā,Supaniyā who was the wife of Demaḷa payā,his daughter Nämbiyā,Daughter of badal Peri and his wife Ādittiyā(*Ibid,* 203-204).According to the information of the inscription, there were many women slaves.

Various economic reasons influenced the women to engage in many occupations. Some women gave paddy as loans with her husband. A husband and wife had given paddy for interest. They lived on the interest continuously. And they earned a lot of wealth. *Saddharmālaṃkāra* describes that (*Saddharmālaṃkāra,*1954: 600).

1.7 Prostitution and woman

Before coming to relevant period, some facts before the period should be referred to. Prostitution was not contempt in contemporary Indian society. According to Indian literature, while they give pleasure to a male, they also earn a lot of money. M. B. Ariyapala tells us about prostitution quoting the studies in Vātsyāna's Kāma Sūtra. He tells that the courtesan held a recognized place in Indian society in the past, and provided amusement and intellectual companionship to anyone who coul afford the luxury, for the *gaṇikās* used to charge exorbitant sums of money for a night. A *gaṇikā* according to Vātsyāyana, was marked out by high intellectual attainments and striking pre- eminence in the arts that she won the coveted title of *gaṇikā*. She must have her mind cultivated and trained by a thorough education and Vātsyāyana lays down that it is only when a courtesan is versed in both the series of 64 arts or *kalās* enumerated by him and is endowed with an amicable disposition, personal charm, and other winning qualities, that she acquires the designation of a *gaṇikā,* and receives a seat of honor in them assembles of men. **(**Ariyapala,1968: 306- 307). According to this description, Indian prostitutes were very respectable than prostitutes of present society.

Hettiaratchi has interpreted the terms relevant to prostitute. (Hettiaratchi, 1988: 110-111). Prostitution is the most ancient profession of women in the world. Although it was a very classic profession in India, it did not affect Sri Lankan women. But it does not mean, Sri Lanka did not have knowledge about prostitution. Although, *Siyabaslakara* was not written in our period, it mentions *abisaru liyan* (Pali and Sanskrit: *abhisārikā*) for the prostitute.**(***Siyabaslakara,* 1933: v. 227). A minister in Mahatittha sent three thousand *kahāpana* for a beautiful woman who stayed on *Sandalutala*. (Sahassavatthu*.,* 1959: 145).*Dhampiyā AṭuvāGāṭapadaya* has the terms such as *gaṇikā, giṇiya, gihiṇiya, giṇi* and *vēsi* (*Dhampiyā AṭuvāGāṭapada*, 1932, 131, 187, 222). Some Sanskrit books give defferent meanings to the words *abhisārikā*, *gaṇikā* to meet

the paramour, according to the early discussion. (*Amarakōṣa***,** Talulakar, 1886: no. 139). Vātsyāyana says that abisārikā needs to have certain qualifications and those are pointed out as being well versed in both sets of sixty four *kalās*, endowed with an amicable disposition, personal charm and other qualities. (Chakladar, 1954: 198). P. V. Kane argues that every *vaishyā* cannot be considered as a *gaṇikā*, they appeared as slave or *dāsi*. (Kane, 1946: 148). However, according to many Indian books (Sharma, 1966: 27-31) as well as Sinhalese sources such as *Saddharmaratnāvali* and *Pūjāvali* the term *gihiṇiya* or *gaṇikā* has been used for any prostitute without any discrimination.

General terms were *abhisaru* and *gaṇikā*. Poems after the writing of *Siyabaslakara,* use the word *abhisaru* very frequently. *Kavsiḷumiṇa* written in the thirteenth century (*Kavsiḷumiṇa,*1994: v. 324) and *Tisara Sandēsa* points out prostitutes by the term *abisaru* (*Tisara Sandēsa,*1991, v. 45). It is very interesting to say that *gihiṇiya* and *gaṇikā* are mentioned in the *Dhampiyā AṭuvāGāṭapadaya* ; *nagara sōbhanā vannadāsi*, *nuwara hobavana vandäs* who brought pleasure to the city; gihiṇiya ū sei. (the courtesan)" (*Dhampiyā AṭuvāGāṭapadaya,*1932: 222). This has been widely interpreted as *nagarasōbhiniṁgaṇikaṁ*. It means prostitute who beautify the city. (*Dhampiyā AṭuvāGāṭapadaya,*1932: 64). It was necessary to say, there was no knowledge of gender in the general public. 111 verse of Sigiri graffiti which can be assigned to the eighth century, *Kavsiḷumiṇa* written in the Dambadeni period of verse of 324 (*Kavsiḷumiṇa,*1994: v. 324) and*Mayūra Sandēśa*, written in the period of Gampola age of ninth verse mentioned the term *abisaru (Mayūra Sandēśa,* 1993: v. 9).

The term mentioned in the Sigiri graffiti and *Mayūra Sandēśa*is very important, because it was not mentioned as not related to on Indian story. The Sigiri poet says that Sigiri women behave as *abisaruvan* or prostitutes. The author of *Mayūra Sandēśa* tells us that there were prostitutes or *abisaruliyan*at homes in the city of Gampola or Gangasiripura expecting paramours. These are main evidences that there were prostitutes or *abisaruliyan* in the Island, even though, prostitution was not a normal occupation. It cannot be determined whether they had a good social condition or economic advantages. The normal worker was paid sixty kahapanas for a month. (Sahassavatthu., 1959: 32). A paramour who had seen the upper part of the body of a woman who was dressed in the evening very beautifully, liked to associate her by paying thousand *kahāpanas*, because he may have thought that she may be a prostitute or abisaru liya. When she did not consent for that money, he increased the money to three thousand kahapanas (Sahassavatthu., 1959: 72). It reveals that prostitutes could earn more than three thousand *kahāpanas* in one night. According to the salary, a prostitute earned a fifty *kahāpanas* more than a general woman worker. She lived in a storyed house, because she is a wife of a richest man. Normally, prostitutes may have lived in these types of houses. The social and economic conditions of her could be realized from this.

In a pre-Brahmi inscriptition, it gives information about prostitution in the period of Pre- State of Sri Lanka. *Shobikā naga kāmina marumakana naṭa cūlaha*(*Inscriptions of Ceylon,* Vol. I, 1970: No. 1010, 79). According to this statement of Sesseruwa inscription, the actor who was named *cūla*, is introduced as the great grandson of a prostitute. All women and men who are mentioned in the Brahmi inscriptions, introduced themselves as a relative of a person of a generation of man. But, the actor named *Cūla* showed his identity by expressing that he came from a prostitute who was his great grandmother. It shows that prostitution was not a disgraceful occupation. An inscription found in Sigiriya, mentions a cave donated by a prostitute who was named *Tosā.*(*Ibid,* No. 1186, 95). King Kumāradāsa and Kālidāsa who were great poets in contemporary India, have been considered as much close friends. (*Pūjāvali*, 1986: 779). When King Kumāra Dhātusēna was living at the palace of Matara in the Southern Province, folklore mentions that he associated with a prostitute and poet Kālidāsa who came to Sri Lanka associated with the same prostitute. (Vanaratana, 1994: 13). According to the views of historians, Kālidāsa who came to Sri Lanka may not be the author who had written *Raghuvaṃsa,*(*Raghuvaṃsa,*1902)*Ritu Saṃhāra,*(*Ritu Saṃhāra,* 1995)*Mēghadūta,* **(***Mēghadūta*, Pandita, 1871),*AbhigñānaŚākuntala*(*AbhigñānaŚākuntala***,** 1995), because there was a gap of about hundred years between the Sri Lankan king and the living period of the great poet Kālidāsa. There were three poets with the name of Kālidāsa in India and one Kālidāsa of the three with them may have come to Sri Lanka in the period

of King Kumāra Dhātusēna. However, the episode of the association of the same prostitute by the king and Kālidāsa is a very vital incident for this research. On a certain day, King Kumāra Dhātusēna went to meet the prostitute or *nagara sōbhini*, and wrote two verses in the Sanskrit language on the wall of the prostitute's home and he mentioned that if some one filled the other two verses, he would be given a *varaya* as well. On the same day, Kālidāsa who came to meet King Kumāradāsa went to the home of the prostitute, saw the two verses written on the wall as mentioned

Padmā da padmānōd bhūtam
Shruyate nava drushyate.

Kālidāsa filled the other two verses as *Bāle tava mukhabhāmbhōjat*
Tvanne trendi varad vayam

Folklore mentions that the prostitute who desired to get the gift from the king filled those two verses and assassinated Kālidāsa. (*Jānakīharaṇa Mahā Kāvyaya*, 1963: XI-XII). This story clearly reveals some facts. Prostitutes were in the society and they were met even by royalties. If the prostitute filled the verses, she may have had the knowledge of Sanskrit language. It should not be forgotten that she was fearless so as to kill Kālidāsa. Finally, it is very clear that a prostitute desires to get wealth.

*Nikāya Saṃgraha*hints that there was prostitution in the period when *Nikāya Saṃgrahaya* was written. According to the statement, a monk went to meet a prostitute in the night and he returned to the vihāra in the morning. **(***Nikāya Saṃgrahaya,* 1987: 31).

Sigiri graffiti mentions prostitutes. Sigiri poet wrote mentioning the displeasure of seeing prostitutes. (Sigiri.Graffiti., Vol. II, No. 3, 1956: 67-68).Due to the displeasure on prostitutes, some Sigiri poets have accused the women in Sigiri, women who go to paramours when there is lack of wealth to get husbands. (*Ibid,* No. 384, p. 239).

Literature, which was written in the period of Dambadeṇi describes prostitution. *Saddarmaratnāvali* presents a statement *nikrushta vū vaishyākam koṭa ävidinā vū*(*Saddarmaratnāvali*, 1985: 617).This expresses the displeasure of Sirima. The autor of *Pujavali* tells about the displeasure of prostitution. (*Pujavali*, 1986: 590).According to the above statement, prostitutes were in the habit of cheating people by pretending that they had no children, even if they had. If their offspring happened to be a boy, he was put to death; and if a girl, she was brought up as a harlot. *Kavsiḷumiṇa* and *Sandēśa* poems have described prostitution. The author of *Tisara Sandēśa*records that prostitutes are fear of the light that was thrown from gems in the town, when they roam the streets. (*Tisara Sandēśa***,** 1991: 45). According to the above poem, prostitution was not an occupation which was not known by the people at this time. The literature describes that due to the courtesans, towns were beautified. *Tisara Sandēśa*says about prostitutes who stayed in the city of Matara, Väligama, Beruvala and Galle (*Tisara Sandēśa***,** 1991: v. 35, 45, 55, 76). According to the sources they associate with paramours. The normal place of prostitution is in the proximity to the beach area. Sometimes, this may be, because foreign merchants came to cities for commercial activities. (Abayarathne, 2009: 293). These women may have had some financial problems. *Mayūra Sandēśa* mentions that there were prostitutes in the city of Gampola. (*Mayūra Sandēśa,*1928: v. 9) But these women were not like those in the *Tisara Sandēśa*. These prostitutes behaved very secretly with their paramours. They walked on roads fearfully. (*Mayūra Sandēśa*, 1993: v. 41) It can be thought that this was a common feature. Although these two books describe in two different ways, it cannot be thought that this happened due to the transformation of social values during this period. The author of *Mayūra Sandēśa* viewed prostitutes in a different way from the prostitutes who had been seen by the author of *Tisara Sandēśa*who lived in Devinuvara which is a suburban area of the coast. *Kavsiḷumiṇa*describes *Abisaruwan* or prostitutes;(*Kavsiḷumiṇa,*1946-47: v. 12).According to the above mentioned prose, the full moon shining over that city reddened by the luster of the rays of red gems of the pandals caused doubt in the minds of the prostitutes whether it was the morning sun. Another verse of *Kavsiḷumiṇa* presents prostitutes.

Duru keḷe aluyam- bera me gos piya taman
Uravil lägume gos gat–abhisaruwan taṇa hasun(*Kavsiḷumiṇa,*1994: v. 324).

The thunder like beating of drums at dawn caused the swans, namely the breasts, of the courtesans, to leave the ponds, the chests, of the lovers, where they had rested during the night.

Sandēśa poets mention *abisaru* or prostitutes in similar situations. *Parevi, Kovul, Haṃsa*and *Sävul Sandēśa* poems have pointed out *abisaryliyan* or prostitutes, when they describe the*toranas*. Re. Tennakon shows similarity of them with examples. The statement of *Parevi Sandēsa* is a translation of *Jānakīharaṇa.*

Yatra kshatōdvrumhitatāmasāni
Raktāshmanīlotpalatōraṇāni
Krōdhapramōdau viddhurvihābhīr
Nārijanasya bhramatō nishāsu.

(*Jānakīharaṇa Mahā Kāvyaya*, 1963: 4, v. 11).(*Parevi Sandēsa*, 1967: v. 15).

According to this verse, there were *abisaru* or prostitutes in the time of torana in the city.

The author of the *Haṃsa Sandēśa* gives the same meaning to a similar verse. (HS, 1953: v. 16) Author of *Kōkila Sandēśa* described prostitutes (*Kōkila Sandēśa*, 1962: v. 256) the same way as the *Tisara Sandēśa* and *Sävul Sandēśa*. (*Tisara Sandēśa***,** 1991: v. 92; *Sävul Sandēśa*, 1969: v. 13).*Kavsiḷumiṇa*points out a similar verse in the *Sävul Sandēśa*. (*Kavsiḷumiṇa,*1994: v. 324). According to the above, there were prostitutes in the period of discussion and Sanskrit books and early Sinhalese literature influenced the writing about the *abisaru liyan* or prostitutes. *Parevi Sandēśa*emphasizes that prostitutes or abisaru went here and there finding paramours in the evening. (*Parevi Sandēśa*, 1967: v. 15). According to the *Sävul Sandēśa*, prostitutes were at *Sītāvaka*, who hit the paramours with bunches of flowers to attract them. (*Sävul Sandēśa*, 1969: v. 22).

Regarding the women of the city, Sandēśa poems describe the women of city or *varanganās*, *puranganās* in places of Kalutota, kalutota river bank, Kälaṇi city, Jaffna, Saparapura and Sītāvaka. There were *Nāgakanyās* among the *puranganas.*(*Sälalihini Sandēśa*, 1972: vs. 43-44). These *nāga kanyās* wear kaḍupul flowers in the hair and their hips were decorated by lighting *maṇimekhalḷ*. Breasts were also decorated. Some *nāga kanyās* were sitting on sand playing the *Vīnā*. They sang songs related Lord Buddha. *Nāga kanyās* were descendents from *Nāga gōtrikas* and Kälaṇiya and suburban areas were very famous for *nāgagōtrikas*.

Authors of Sandēśa poems have praised women of Sri Jayawardhanapura Kotte very highly. (*Parevi Sandēśa*, 1967, v. 9, 12- 14).(*Kōkila Sandēśa*, 1962, v. 126-131).(*Tisara Sandēśa,*1991: v. 22-26; 54-55).(*Haṃsa Sandēśa*, 1960: v. 18-19; 21-22). Sri Rahula thera praised the women in Kotte than other authors. (*Sälalihini Sandēśa*, 1972: 12). This means that their face was like the moon and the hip could be taken by hand. waists were very slender and breasts were similar to swans. These women were similar to goddesses, if they did not blink eyes. Entertainments could also be heard of *puranganas* or women of the city. Playing in grounds and playing in water were some of entertainments of the women of the city. (*Sälalihini Sandēśa*,, 1972: vs. 45-46).

According to these two verses, these women of the city played on the ground and in the water with paramours. These women were dressed with beautiful *Sapu* flowers in their hair and breasts and ears were decorated with some flowers.

Women of elite society spent very luxurious life and *Tisara*and *Mayūra Sandēśas* describe many aspects of that. According to the *TisaraSandēśa*, the main cities (*TisaraSandēśa***,** 1991: v. 10, 100, 105, 149) were decorated by women who had good qualities and excellent knowledge. (*TisaraSandēśa*,,1991: v. 10) Those women walked on the balconies(*TisaraSandēśa*,**,** 1991: 13) and **sivu mäduru kavulus** (*TisaraSandēśa*,**,** 1991, 16). The women, who have a golden light body, (*TisaraSandēśa*,**,** 1991: v. 15, 77, 80) painted **lāksha i**n their feet. (*TisaraSandēśa*,**,** 1991: v. 13). These wealthiest younger women painted their hands and legs with various colors. Some dots were kept on the eye brows. (*TisaraSandēśa*,**,** 1991: v. 148). They played with balls produced by lākaḍa. (*TisaraSandēśa*,**,** 1991: v. 75). This game was very famous among the women. (*TisaraSandēśa*,**,** 1991: v. 149, 176). Although these descriptions are exaggerated, they reveal that elite women of this society had spent a very luxurious life. Some sources reveal that there were dancing women in this period. They danced in many places. (*TisaraSandēśa*,**,** 1991: v. 14) While dancing the women sang songs

of praise (prasastis) to the king (TS**,** 1938: v. 170) and they danced in the king's palace. (*TisaraSandēśa*,**,** 1991: v. 171) They danced attractively according to music (*TisaraSandēśa*,**,** 1991: 173). (*TisaraSandēśa*,**,**1991: vv. 174-182). Those who stayed in Kelaniya city, danced very attractively in front of God Vibhīshana. (*MayūraSandēśa*, 1993: v. 37). These dancers had presented their abilities to God Upulvan in the Devinuwara Devalaya. (*MayūraSandēśa*,, 1993: v. 122).*Mayūra Sandēśa* mentions that those women were very beautiful (*MayūraSandēśa*,, 1993: 123) and they danced according to the *nūpura* (*MayūraSandēśa*,, 1993, v. 124) with glancing the corner of the eyes (*MayūraSandēśa*,, 1993: v. 125) and they sang very beautifully. (*MayūraSandēśa*,, 1993: v. 126). They wore bracelets and earrings. (*MayūraSandēśa*,, 1993: v. 127). All those are poetic expressions. But those expressions suggest the existed pattern of dresses.

In the light of foregoing discussion, it can be concluded that Women certainly occupied a favorable position in the economic history of the Island. She lived a comfortable life as she can, according to the necessities of the agricultural society. Even though, there was a patriarchal society, she assisted to develop her husband to maintain the economic life of the house and the country.

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Knowledge Strategy and Innovation in Manufacturing Firms in Kenya

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ABSTRACT

Current research in the field of strategy suggests that organizational knowledge is critical in enhancing a firm's innovation. The objective of this study was to empirically examine the effect of knowledge strategy on organizational innovation. The study adopted cross-sectional survey research design. The target population comprised of 655 manufacturing firms in Kenya. A stratified sample of 266 firms representing twelve sub-sectors of manufacturing sector was used. Primary data was collected from 184 firms using structured questionnaire administered to the managers of the firms. The results show that knowledge strategy has a positive and significant effect on innovation activities of the firms. It is concluded that higher levels of knowledge strategy would result in higher organizational innovation.

Keywords: Knowledge strategy, Knowledge exploration, Knowledge exploitation, Organizational innovation

1. INTRODUCTION

In the last two decades, there has been an increasing interest in organizational knowledge as a source of competitive advantage. The view of knowledge as a primary asset is considered as an extension of the resource-based view of the firm that is specifically knowledge-based (Meso & Smith, 2000). The need to focus on managing knowledge within firms resulted from changes in customer demands, changes in technology and increased global competition (Wiig, 1997; Drew, 1999) and firms saw the creation and exploitation of knowledge as a true source of competitive advantage and success. The realization of the importance of knowledge in determining firm competitiveness has been increasing over time.

Knowledge strategy is a relatively new concept in knowledge literature. Knowledge strategy is part of knowledge management (KM) and refers to the overall approach an organization intends to take regarding the focus of its resources on knowledge exploration and knowledge exploitation (March, 1991; Zack, 1999). Thus, knowledge strategy describes a firm's strategic choice on whether the firm focuses more of its resources on knowledge exploration, which deals with the creation, discovery or acquisition of new radical knowledge; or knowledge exploitation that is, incremental refinement, reuse or efficiency in existing knowledge base (March, 1991; Bierly & Daly, 2007). Knowledge exploration is more innovation-oriented and exploitation aims at attaining efficiency (March, 1991; Bierly & Daly, 2007). The overall purpose of knowledge strategy is to enable an organization maximize effectiveness and returns from its knowledge assets. Strategy scholars and practitioners believe that a well-balanced combination of knowledge exploration and exploitation is essential for a healthy organization (Tushman & O'Reilly, 1996).

Innovation is viewed as one of the fundamental organizational activities in the market. Innovation is defined as a new idea, method or process of introducing something new (Sarros, Cooper & Santora, 2008). Thus organizational innovation refers to the introduction of a new product or process, or new ways by an organization. Organizational innovation in terms of development of new products and processes is an important source of sustainable competitive advantage and superior performance (Damanpour, 1991; Eshlaghy & Maatofia, 2011; Sarros et al., 2008).

Innovation constitutes an indispensable component of corporate activities in that it enables a firm to apply new productive manufacturing processes, to respond to changing customer needs, attain positive reputation in customers' perception and as a result, gain sustainable competitive advantage and superior performance (Eshlaghy & Maatofia, 2011). Eshlaghy and Maatofia argue that through the development of organizational capabilities and aligning them to the dynamic environment, innovation strengthens an organization's competitive advantage and enhances performance.

The goals and expected outcomes of an organization with effective KM are many; for example, KM can be seen as a way to improve organizational effectiveness (Wiig, 1997; Armistead & Meakins, 2002) and becoming a more innovative organization (Kaser & Miles, 2002), hence a source of competitiveness and improved performance (Nonaka, 1994; Armistead & Meakins, 2002).

Theoretical literature suggests that through stocks of knowledge, a firm is able to innovate new products and processes which gives it competitive advantage. In spite of the theoretical linkage between organizational knowledge and innovation, prior empirical studies have not focussed on the linkage between knowledge strategy and organizational innovation. Further, past studies that have examined the linkage between KM initiatives and organizational performance have conceptualized KM in terms of knowledge acquisition and dissemination. Manufacturing firms in Kenya are managing organizational knowledge as a resource to enhance their competitiveness and performance (Cheruiyot, Jagongo & Owino, 2012; Mwihia, 2008). However, past studies have not examined the effect of knowledge strategy on the innovation activities of the firms. Hence this study sought to examine the effect of knowledge strategy in terms of knowledge exploration and exploitation on innovation of manufacturing firms in Kenya.

The rest of the paper is organized as follows: the next section reviews related literature and research hypothesis. This is followed by an overview of the research methodology, which discusses the population, sample, data collection, measurement of variables and data analysis techniques. The fourth section presents the results and discussions. The fifth section presents conclusions of the study.

2. LITERATURE REVIEW

Knowledge Management literature suggests that innovative capacity highly depends on organizational knowledge and its management. Knowledge often contains new ideas and hence knowledge creation and sharing is seen as a main requisite and an antecedent of innovation and competitiveness (Darroch & McNaughton, 2003; Nonaka, 1994). An organization's innovativeness depends on its ability to utilize its knowledge resources since innovation process involves the acquisition and use of new and existing knowledge (Damanpour, 1991; Nonaka, 1994). Increasing the amount and quality of knowledge sharing within organizations creates new insights crucial to creating higher levels of innovation. Thus, innovation enables organizations to translate knowledge about ideas and markets into practice.

Wiig (1997) argues that creation of new knowledge and sharing of the knowledge brings innovation and firms' continued ability to create and deliver new products and services to meet the changing customer needs. It is widely accepted that increasing the amount and quality of knowledge sharing within firms is crucial to creating higher levels of innovation (Kaser & Miles, 2002). The expected outcome of an organization with effective KM is the organization's ability to innovate through improved processes or products and services. New knowledge triggers new insights that drives product and process innovation hence enhanced innovative performance of firms (Kaser & Miles, 2002).

Extant literature suggests that firms can innovate either through knowledge exploitation designed to meet the needs of current markets by leveraging existing knowledge or through knowledge exploration designed to

meet the needs of new markets by pursuing new knowledge (Jansen, Vera & Crossan, 2009). Past empirical studies (Darroch & McNaughton, 2003; Jansen, Vera & Crossan, 2009) have shown that firms adopting more KM practices in terms of knowledge dissemination were more innovative in terms products and processes. In a survey study examining KM and the innovativeness of New Zealand firms, Darroch and McNaughton (2003) found that firms adopting more KM practices were more innovative in terms of new products and processes.

A study of Chinese firms (Li, Liu, Wang, Li & Guo, 2009) examining how entrepreneurial orientation moderates the effects of knowledge management on innovation found that intrafirm knowledge sharing has a statistically significant positive impact on innovation. The study indicated that internal knowledge sharing is necessary for the enhancement of innovation.

In another study examining the relationships between knowledge codification, exploitation and innovation in Chinese firms, Li, Lee, Li and Liu (2010) found a positive relationship between knowledge exploitation and innovation. They concluded that competitive advantage of firms depends not only on knowledge creation, but also, on knowledge exploitation process to achieve innovation objectives.

In a recent study (Lopez-Nicholas & Merono-Cerdan, 2011) examining the effect of strategic KM (codification and personalization) on firm innovation and performance among Spanish companies found that both KM strategies positively impact on corporate innovation and organizational performance. However, they did not find difference regarding the impact of each KM strategies (personalisation and codification) on innovation.

Based on the above arguments and empirical evidence, the following hypothesis was proposed:
H1: Knowledge strategy has a positive effect on organizational innovation.

3. RESEARCH METHODOLOGY

3.1 Population and Sample

This study focussed on the influence of knowledge strategy and innovation of manufacturing firms in Kenya. The population of the study comprised all manufacturing firms in Kenya. The firms which comprise the population of the study were identified using the Directory of Kenya Manufacturers and Exporters (KAM) (KAM 2014), which the researcher established maintains the most update coverage of manufacturing firms in Kenya.

There were a total of 655 manufacturing firms at the time of the study which were members of KAM (KAM, 2014). The firms are classified into 12 sub-sectors of manufacturing on the basis of the products they manufacture. The sub-sectors are: Food, Beverages and Tobacco; Metal and Allied; Leather and Footwear; Chemical and Allied; Textile and Apparels; Plastics and Rubber; Paper and Board; Timber, Wood and Furniture; Pharmaceutical and Medical Equipment; Motor Vehicle and Accessories; Energy, Electricals and Electronics; and Building, Mining and Construction Sector.

Given the large size of the population and resource constraints, a sample of 266 firms was used for this study. To select the 266 firms which constituted the sample units, disproportionate stratified random sampling was used to ensure the sample was representative of the 12 sub-sectors of manufacturing.

3.2 Data Collection

To achieve the objective of this study, primary data was collected using a structured questionnaire. The questionnaire was developed to measure the respondents' perceptions of the existence and magnitude of the research variables: knowledge strategy and organizational innovation in their organizations.

The unit of analysis in this study was the organization; hence one respondent was targeted in each firm. The respondents were the executive officers of the firms who included chief executive officers, production managers, human resource managers and administrators. The managers were considered to be better informed about organizational characteristics and processes.

3.3 Description of Measures

The survey contained a number of measures designed to elicit information about the study variables: knowledge strategy and organizational innovation. The variables were operationalized by borrowing from related past studies as discussed below.

The independent variable of this study, knowledge strategy was measured using the widely used dimensions of knowledge exploration and exploitation (Bierly & Daly, 2007; March, 1991; Miller et al., 2007). Informed by the literature, five-point Likert-type response scales (from 1 = strongly disagree to 5 = strongly agree) were constructed with items on knowledge exploration and exploitation. Respondents were asked to indicate how accurately each statement described their firms. A higher agreement with the statements in the scale was taken to mean the organization practiced knowledge exploration and exploitation to a great extent.

Organizational innovation was measured in terms of introduction of new or improved products to the market, and new or improved processes. Items to measure innovation were borrowed from the works of Darroch and MacNaughton (2003) and Li et al. (2009). Five-point Likert-type scales (from 1 = strongly disagree to 5 = strongly agree) were developed with items to measure the dimensions of organizational innovation. Respondents were asked to indicate their level of agreement on how accurately the statements about innovation described their firms. Higher agreement with the statements in the scale was taken to mean the organization was innovative in products and processes.

Past studies (Bierly & Daly, 2007; Gopalakrishnan & Bierly, 2006) have shown that age and size influence organizational processes. Hence the variables were controlled for in this study. Age was measured using the number of years the organization has been in operation; and size of the organizations was measured using the number of permanent employees.

3.4 Data Analysis

Descriptive statistics, specifically the mean and the standard deviation were used to describe the research variables. Pearson's product-moment correlation was used to examine how the dimensions of the independent variable, knowledge strategy were related with the dependent variable, organizational innovation.

To test the research hypothesis (H1), which predicted that knowledge strategy has a positive effect on organizational innovation, multiple regression analysis was used. Organizational innovation was regressed on the dimensions of knowledge strategy that is, knowledge exploration and knowledge exploitation. Composite scores of knowledge exploration and knowledge exploitation, and organizational innovation were used in the analysis. The following multiple regression model (1) was developed:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \varepsilon \quad \text{.....(1)}$$

Where: Y is the dependent variable (organizational innovation), β_0 is the Y intercept, β_1 and β_2 are the regression coefficients, X_1 is knowledge exploration, X_2 is knowledge exploitation and ε is regression error term.

4. RESULTS AND DISCUSSION

4.1 Response Rate

The unit of analysis in this study was the organization as each organization has unique sets of knowledge strategy and organizational innovation. Questionnaires were distributed to 266 companies. After follow-ups, questionnaires from 184 companies were completed and returned in a form usable for analysis, which constituted a response rate of 69 percent.

4.2 Descriptive Statistics

4.2.1 Knowledge Strategy

The study sought to describe knowledge strategy of the firms. Respondents were asked to indicate the extent to which they agreed that the statements on the items of dimensions of knowledge strategy described their firms. Table 1 presents the results of the analysis.

Table 1: Mean and Standard Deviation for Measures of Knowledge Strategy

Knowledge strategy items	*N*	Mean	Std. Deviation
Knowledge Exploration		**3.84**	
We frequently experiment with radical new ideas	183	3.82	.82
At our firm employees frequently come up with creative ideas that challenge conventional ideas	183	3.79	.82
Compared to our principal competitors, a high percentage of our firm's sales come from new products launched within the past 3 years	181	3.84	.86
We are usually one of the first firms in our industry to use new breakthrough technologies	182	3.90	.84
Knowledge Exploitation		**4.11**	
At our firm a strong emphasis is placed on improving efficiency	182	4.14	.77
Our firm excels at refining existing technologies	184	4.07	.77
We frequently adjust our procedures, rules and policies to make things work better	184	4.10	.74
Overall		**3.98**	

As shown in Table 1, the mean score for the knowledge exploration dimension was 3.84. The mean for knowledge exploitation dimension was 4.11. The overall mean score for knowledge strategy was 3.98. These results indicate that the respondents strongly agreed with the statements regarding knowledge strategy in their organizations. These results were interpreted to mean that the firms practice knowledge strategy that is, both knowledge exploration and knowledge exploitation strategies to a great extent. However, the organizations exhibit slightly more of knowledge exploitation ($M = 4.11$) than knowledge exploration ($M = 3.84$).

The findings of this study are consistent with the findings of past studies (Bierly & Daly, 2007; March, 1991) which found that the two knowledge strategies- knowledge exploration and exploitation are complementary and a firm can pursue both strategies simultaneously, supporting the ambidextrous view that firms need to balance between knowledge exploration and exploitation (March, 1991). The results are also consistent with past studies in Kenya (Mwihia, 2008; Cheruyoit et al., 2012) which found that firms in Kenya were managing knowledge as a resource to enhance their effectiveness and efficiency. This study adds to these prior studies by providing understanding that manufacturing firms in Kenya practice knowledge exploration and knowledge exploitation strategies.

4.2.2 Organizational Innovation

The study sought to describe innovation activities of the firms. Respondents were asked to indicate the extent to which they agreed that the statements of items of product and process innovation described their firms. Table 2 presents the results of the analysis.

Table 2: Mean and Standard Deviation for Measures of Organizational Innovation

Organizational Innovation	*N*	Mean	Std. Deviation
Product innovation		**3.98**	
Our firm often creates and commercializes products with totally new performance	182	4.00	.80
Our firm introduces new products to the market before competitors	183	3.89	.82
Our firm often improves existing products	182	4.04	.80
Process innovation		**4.05**	
Our firm often introduces new production processes and methods	182	4.05	.81
Our firm often improves production processes and methods	182	4.06	.69
Overall Mean		**4.02**	

The results presented in Table 2 indicate that the mean for the items for product innovation was 3.98. The mean for process innovation was 4.05. The overall mean for organizational innovation was 4.02. These scores indicate that the respondents agreed with the statements regarding aspects of innovation in their organizations to a great extent. On the overall, the results show that the firms practice both product and process innovation activities.

4.3 Correlation Analysis

The study examined the relationship between knowledge strategy and organizational innovation. The analysis was done using Pearson product moment correlation. The output of the analysis is presented in Table 3.

Table 3: Correlation Matrix for Knowledge Strategy and Organizational Innovation

		Knowledge Exploration	Knowledge Exploitation	Organizational innovation
Knowledge exploration	Pearson Correlation	1		
	Sig. (1-tailed)			
	N	180		
Knowledge exploitation	Pearson Correlation	.581**	1	
	Sig. (1-tailed)	.000		
	N	179	182	
Organizational innovation	Pearson Correlation	.487**	.309**	1
	Sig. (1-tailed)	.000	.000	
	N	178	180	182

** Correlation is significant at the 0.05 level (1-tailed)

The results in Table 3 show that there is positive and significant relationship between knowledge exploration and organizational innovation ($r = 0.487$, $p < 0.05$). The results also show that the relationship between knowledge exploitation and organizational innovation is positive and significant ($r = 0.309$, $p < 0.05$). Thus

the results show that both dimensions of knowledge strategy are positively and significantly related to organizational innovation.

4.4 Test of Hypothesis

The research hypothesis which stated that knowledge strategy has a positive effect on organizational innovation was tested using multiple regression analysis. Organizational innovation was regressed on the two dimensions of knowledge strategy that is, knowledge exploration and knowledge exploitation. The results of the analysis are presented in Table 4.

Table 4: Multiple Regression Results for Effect of Knowledge Strategy on Innovation

Variable	Model 1	Model 2
Constant	3.728	2.020
Age	.077	.061
Size	.077	-.011
Knowledge exploration		.463*
Knowledge exploitation		.036
R^2	.015	.242
F	1.309	13.792
R^2 Change		.227*
F Change		25.903*

*$p < .05$

The results in Table 4, show that R Squared for Model 1 is 0.015, indicating that 1.5% of the variation in organizational innovation is explained by variation in the control variables (age and size). Model 2 shows that after knowledge exploration and exploitation were added, R Squared increased to 0.242 which means that 24.2% of the variance in organizational innovation is explained by the control variables and the knowledge strategies. Model 2 shows that R Squared change is 0.227. This shows that the two knowledge strategy dimensions (knowledge exploration and exploitation) explain an additional 22.7% of variation in organizational innovation. The results indicate that the change in R squared is statistically significant (F change = 25.903, $p < 0.05$). Thus the results indicate that knowledge strategy has a significant effect on organizational innovation, supporting hypothesis H1. The results also indicate that both dimensions of knowledge strategy, knowledge exploration and knowledge exploitation have a positive effect on organizational innovation. However, knowledge exploration has a greater effect on organizational innovation ($\beta = 0.463$) than knowledge exploitation ($\beta = 0.036$).

The finding of this study is consistent with Darroch and McNaughton's (2003) finding that firms adopting more KM initiatives in terms knowledge acquisition and dissemination were more innovative in terms of new products and processes. These findings support the view that innovative capacity depends on organizational knowledge (Darroch & McNaughton, 2003). Knowledge often contains new ideas, and knowledge creation and sharing enhances innovation. The finding that knowledge exploration has a greater effect on

organizational innovation than knowledge exploitation can be explained by the view that knowledge exploration is innovation oriented while knowledge exploitation focuses on efficiency (March, 1991; Bierly & Daly, 2007).

5. CONCLUSION

The objective of the study was to determine the effect of between knowledge strategy on organizational innovation. The results reveal that knowledge strategy has a positive and significant effect on organizational innovation, which supports hypothesis H1. Further, regarding the relative influence of the dimensions of knowledge strategy on organizational innovation, regression results indicate that knowledge exploration has greater effect on organizational innovation than knowledge exploitation.

Thus, it is concluded that there is a linkage between knowledge strategy and organizational innovation; and knowledge strategy has a positive and significant effect on organizational performance. Hence, higher levels of knowledge strategy results in higher innovative performance in products and processes.

The findings of this study imply that knowledge strategy (knowledge exploration and exploitation) is essential for higher innovation performance. Hence, to enhance organizational innovation and competitive advantage, organizations need to focus their resources on knowledge exploration and exploitation.

This study has made a contribution in understanding the effect of knowledge strategy on organizational innovation in a developing country context. However, the study has some limitations. This study adopted a cross-sectional survey. Such studies have limitations on providing explanations on the linkage between variables. Thus, future research should adopt longitudinal research designs in data collection to enhance understanding of the relationship between the knowledge strategy and organizational innovation. The respondents of this study were executive officers and single respondents were used to collect data. To minimize the effect of single respondent bias, future research can use multiple respondents including executive officers and middle managers.

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Comparison Between The Rate of Transpiration of *Rauvolfia serpentina* In a Water Sufficient and Water Deficit Environment

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Transpiration rate is influenced by several external abiotic factors. It can be modified by climate change leading to variations in cell morphology. This study generally aimed to compare the rate of transpiration between water-sufficient and water-deficit environment using Rauvolfia serpentina. It specifically aimed to assess the difference in cellular morphology in roots, stems, and leaves of Rauvolfia serpentina under water water-sufficient and water-deficit environment. Results showed that factors influencing transpiration rate, namely, light, wind, humidity, temperature and soil water have a great impact on the cell morphology of a plant. Hence, high transpiration rate is indicative of proper uptake of carbon dioxide, large production of chlorophyll and good transportation of nutrients throughout the plant parts. Furthermore, low transpiration rate exhibits stomata closure leading to decreased uptake of carbon dioxide, chlorophyll deficiency and nutrient-deficit transport system.

Keywords: transpiration rate; biodiversity; climate change; drought; serpentina

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I. Background of the Study

Biodiversity includes measurement of the variation of species and its ecosystem, biome or planet. It plays an important role in the stability, sustainability, productivity and other services of ecosystem that are vital to the health of human being. Loss of biodiversity has become a serious issue in many areas in the world. Global climate change is often considered as one of the major determinants of biodiversity loss (Hui, 2013).

Aside from the fact that general temperature increase global change, models have predicted more often and more serious extreme climatic events such as drought periods, heat waves or flooding (Feller and Vaseva, 2014). Drought is one of the major abiotic stress determinants that restrict plant growth and have drastic effects on the ecosystem productivity. Stomatal closure is a typical interim reaction to drought stress, leading to a reduced CO2. As a consequence the transpiration of the plant will be influenced, along with its tolerance to drought stress (Mantovani, et al, 2014).

Transpiration is an important physiological process that would keep the plants healthy. It transports water and mineral nutrients from soils to plants and it helps plants to dissipate heat. Microclimates characterized by solar radiation, wind, vapor pressure deficit, soil water content, rainfall, and temperature are the main external factors on tree transpiration (Wang, 2011).

This study generally aimed to compare the rate of transpiration between water-sufficient and water-deficit environment using *Rauvolfia serpentina*. It specifically aimed to assess the difference in cellular morphology in roots, stems, and leaves of *Rauvolfia serpentina* under water water-sufficient and water-deficit environment. Factors affecting transpiration rate were clustered into settings of water-sufficient and water-deficit environment.

II. Materials and Methods

A. Materials

Two (2) clay pots with small *Rauvolfia serpentina* were planted with enough soil. 7 liters of water were prepared for water-sufficient plant, whereas, 210 mL of water were ready for water-deficit plant. Weighing scale was used for daily measurement of clay pots with *Rauvolfia serpentina* comparing water-sufficient and water-deficit environments.

B. Experimental Set-up

Water-deficit plant was kept inside a room, while, water-sufficient plant was exposed in the surrounding. No sunlight, humid air and small amounts of water were treated to water-deficit plant. Factors affecting to a higher transpiration rate were given to water-sufficient plant.

C. Experimental Procedure

Each clay pot with *Rauvolfia serpentina* was weighed daily expressed in grams. Water-deficit *Rauvolfia serpentina* was given 30 mL of water a day for seven days, whereas, water-sufficient *Rauvolfia serpentina* was given 1,000 mL of water a day for one week. Transpiration rate was computed by dividing the product of total volume of water lost in mL and number of hours in one week by total daily weight of pots treated with corresponding volume of water (Chaurasia, et al, 2013).

III. Results and Discussion

A. Transpiration Rate Results

The table below shows that factors affecting transpiration rate, namely, sunlight, absence of humidity and high breeze resulted in a higher transpiration rate of 73.64 mL/g/hr. *Rauvolfia serpentina* exposed in water-deficit environment reached a transpiration rate of 0.23 mL/g/hr due to limited water supply and moisture absorption due to humid environment.

Table I. Water-Sufficient Transpiration Table

No. of Days	Weight of Pot	Weight of Water	Total
1	1,000g	1,000g	2,000g
2	1,000g	1,000g	2,000g
3	1,000g	1,000g	2,000g
4	1,100g	1,000g	2,100g
5	1,200g	1,000g	2,200g
6	1,100g	1,000g	2,100g
7	1,200g	1,000g	2,200g

Table II. Water-Deficit Transpiration Table

No. of Days	Weight of Pot	Weight of Water	Total
1	1,000g	30g	1,030g
2	1,000g	30g	1,030g
3	1,000g	30g	1,030g
4	1,000g	30g	1,030g
5	1,100g	30g	1,130g
6	1,000g	30g	1,030g
7	1,100g	30g	1,130g

B. Results on Cell Morphology (CM)

Microscope analyses under high power objective (HPO) and low power objective (LPO) illustrate that green pigmentations due to the presence of chlorophyll in chloroplasts were abundant since the specimen was exposed to sunlight and performing photosynthesis. Furthermore, stomata are distinct and prominent due to continuous absorption of carbon dioxide in the surroundings. Dark green pigments of chlorophyll were also observed in the lateral meristem due to the absorption of sunlight in the stem, thus, abundant amounts of chlorophyll were also present. Roots are rich in nutrients for transportation

to different parts of the plant due to sufficient supply of water (Figure 1).

Figure1.Water-Sufficient CM

Cell morphologies of the different parts of *Rauvolfia serpentina,* namely, stem, leaves and roots, exposed to water-deficit environment, were observed under high power objective (HPO) and low power objective (LPO) for analyses. Illustration below reveals lower amounts of chlorophyll in chloroplasts due to the absence of sunlight. Moreover, stomata are closed and almost invisible to view, hence, carbon dioxide uptake was inhibited. Dull green pigments were observed in the lateral meristem due to poor absorption of sunlight. Roots are nutrient-deficient due to short supply of water given to the soil for its uptake (Figure 2).

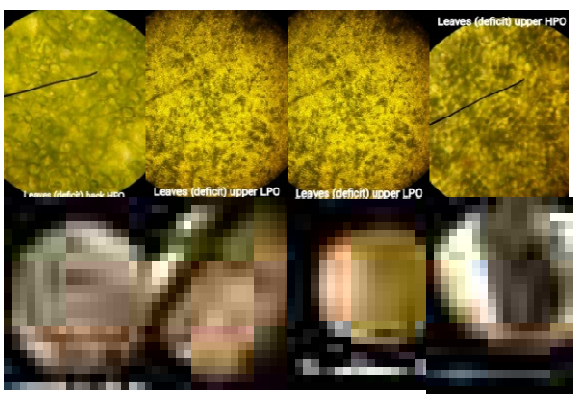

Figure2.Water-Deficit CM

IV. Conclusion

Factors influencing transpiration rate, namely, light, wind, humidity, temperature and soil water have a great impact on the cell morphology of a plant. Hence, high transpiration rate is indicative of proper uptake of carbon dioxide, large production of chlorophyll and good transportation on nutrients throughout the plant parts. Furthermore, low transpiration rate exhibits stomata closure leading to decreased uptake of carbon dioxide, chlorophyll deficiency and nutrient-deficit transport system.

V. Recommendation

This study recommends to conduct transpiration kinetics to other life forms of species affected by climate change and to measure accumulated carbon dioxide concentration by the plant.

VI. References

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EFFECTS OF LAND-USE AND LAND-COVER CHANGE ON LAND DEGRADATION IN KIJABE – LONGONOT CATCHMENT, KENYA.

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ABSTRACT

Changes in land use and land cover (LULC) affect ecosystems, biodiversity and goods and services they provide to society. The magnitude of change varies with time period examined as well as the geographical area. A case study was done at a catchment covering part of highland, escarpment and valley bottom in Kijabe-Longonot area in Kenya. The objective of the study was to assess land use and land cover change and the impact on the landscape. Aerial photographs and satellite images of between 1970 and 2000 were used to assess and classify LULC for different years. Geographical information system (GIS) was used to compare the diverse data sets and the area under different land use systems. The results show a general trend of decrease in forest cover and increase in the area under settlement and farms. The rate of annual deforestation shows that by the year 2060 the forest cover will be less than 5 % if the trend is unabated. As the high rate of deforestation continues, land degradation is expected to increase and will lead to decreased land productivity and hence food insecurity. The major impact of LULC change was accelerated soil erosion by wind and water. Corrective measures can be initiated by re-forestation and soil and water conservation interventions.

Key Words: Time Series Analysis, Deforestation, Kijabe-Longonot, Kenya.

INTRODUCTION

Determining the effects of land use and land cover (LULC) change of an area depends on understanding the past land use practices, current and projections to future patterns. Land use is affected by various factors including human activities, population size and distribution, economic development and change of technology among others (Gitz and Ciais 2003). The changing climate can also affect LULC (Briassoulis, 2000). Loss of biodiversity or changes in composition of plant species in any area gives an indication of severity of pressure on the land by human and animal influence. Loss of vegetation cover usually results from combination activities including overgrazing, cultivation, forest fires and wood exploitation for construction and fuel (Barnes 2008). Forest cover is the most sensitive component of landscape that influences other processes. Deforestation has been going on in many parts of the world causing adverse effects such as loss of biodiversity in animal and plant species, soil erosion, flooding and climate change (Butler, 2007). The effect of deforestation is felt within the local area and also internationally depending on the magnitude. Studies by Avissar and Werth (2004) show that deforestation in large tropical forests affect the pattern of global rainfall. Deforestation in Southeast Asia alters rainfall in China and the Balkan Peninsular (Barnes, 2008.). Deforestation may change the microclimate of an area but may not change the seasonal rainfall in the short

term. Land degradation that result from deforestation is mainly due to exposure of soil to erosion forces of surface runoff and high wind velocities.

Kijabe-Longonot catchment is a semi-arid area which has experienced LULC changes since 1970s due to human activities on the land. Originally in the 1950s the pastoral Maasai community as well as European settlers used the area for livestock grazing (Gathuru *et al.,* 1986). People from Central province through cooperative societies and land-buying companies bought the land in the late 1960s and early 1970s. The land was sub-divided into plots of 2 ha and allocated to shareholders (Mburu, 1983). Since the time when most people migrated to the area in 1970s, there have been changes on the landscape that have negatively affected land productivity. Research was carried out in the area for two years to assess the LULC changes that occurred over a period of 30 years between 1970 and 2000. The research objectives were to:

i. Compare land use cover at different time intervals.
ii. Assess the land use and land cover (LULC) changes between 1970 and 2000.
iii. Assess land degradation problems associated with LULC change.

MATERIALS AND METHODS

Location and description of study area

Kijabe-Longonot catchment is situated in the central part of the Kenya's Rift Valley, southeast of Lake Naivasha, and about 70 km northwest of Nairobi. The area spreads at altitudes of between 2,100 m above sea level in the upland and 1,700 m above sea level in the valley. It is bounded by latitudes 0° 49´ S to 0° 53' S and longitudes 36° 27' E to 36° 29' E and administratively falls under Naivasha Sub-County of Nakuru County (Figure.1). The area has experienced both faulting and volcanic activity and has volcanic sediments and lacustrine deposits (Thompson, 1964). The study area covered about 885 ha including the highland forest, Kikuyu escarpment, Kijabe hill and the Ewaso Kedong Valley.

The study area covered in the aerial photographs and satellite images was 885 ha. The area comprised four physiographic units namely; the Upland, Escarpment, Kijabe hill and the Valley (Fig 1). The upland was initially forested with most of the land under planted forest, and receives an average annual rainfall of 1250 mm. The land has undulating topography with slopes of between 5-15 %. The soils are more than 200 cm deep.

The escarpment had both planted and natural forest and characterized by steep slopes (30-60 %) and shallow soils (20-50 cm) with rock outcrop in some areas. It receives an average annual rainfall of 700 mm.

Kijabe hill is between the escarpment and the valley. Initially the area was covered with shrub grassland. The slopes are steep (35-60 %) and people have settled round the hill. It receives an average annual rainfall of 630 mm.

The valley was initially characterized by shrub grassland and has gentle slopes of less than 5 % and receives an annual rainfall of 600 mm. The area has shallow to deep soils (20-180 cm) and has been severely degraded by water and wind erosion. About 60 % of the valley is under high risk of soil erosion. Some areas have lost most of the top soil leaving exposed sub-soil that has poor physical characteristics and low fertility.

Methodology

The assessment of land use and land cover (LULC) change was done by interpreting aerial photographs and satellite images of different time intervals with a common classification scheme. Aerial photo interpretation was manually done using a pair of mirror stereoscopes. The available aerial photographs were of different

1970 and 1982 were acquired from the Survey of Kenya while the ones of 1990 were acquired from Photomap (Kenya) Limited. The aerial photographs were arranged in order according to flight sequence and 60 % overlap to form mosaic coverage of the study area. Three LULC maps corresponding to three time series and one erosion map were developed. The features interpreted included planted forest, natural forest, cleared forest, settlement, cultivation and eroded areas.

The available Landsat 1 image of 1975 with ground resolution of 80 metres, and Landsat 5 image of 2000 with ground resolution of 79 metres were interpreted using supervised classification method given by Lillesand and Keifer (2000). The satellite images were obtained from the Regional Center for Mapping Resources for Development (RCMRD) in Nairobi. Due to low resolution of the satellite images, land use and land cover classification could not be done as detailed as was done in the aerial photographs. Supervised classification of the interpreted features in the satellite images was mainly on forest cover. Two maps from the two time series images of 1975 and 2000 were developed that showed the extent of forest cover in each year.

The supervised LULC classification was based on the researcher's knowledge of the study area, correlating interpreted features with the ones in the topographical map and adjustments made during ground-truthing. The area under settlement and cultivation had distinct patterns that were easy to identify in the aerial photographs. The planted and natural forest could be identified by the vegetation density, texture and pattern. Areas of cleared forest had distinct boundaries and easy to identify. Erosion features like gullies could be recognized in the aerial photographs. Areas under wind, rill and inter-rill erosion were identified on the basis of tone and shape. The extent of coverage was assessed through ground-truthing. LULC maps developed for each time series were used in Geographical Information System (GIS) for further analysis. The developed LULC maps were geo-referenced in the GIS using topographical map of the area (Kijabe sheet No.134) of scale 1:50,000. The boundary of the study area was established on the topographical map and the selected coordinates were digitized. Universal Transverse Mercator (UTM) coordinates system was used where the coordinate numbering is directly correlated to a distance measuring system that makes it easy to determine the area in hectares. The coordinates of selected ground control points like road junctions were transferred to the generated LULC maps. Digitization was done using ARCINFO software. All the digitized LULC maps were made to conform to one scale (1:16,000) where common features in the aerial photographs and the satellite images were identifiable. The digitized LULC maps were used in ARCVIEW GIS programme version 3.3 which has overlay capability of comparing different data sets for the same area. The area under each LULC class was automatically calculated in hectares.

RESULTS AND DISCUSSIONS

Land use and land cover change

In 1970 the largest part of the valley was shrub grassland and the land use was mainly livestock grazing. A few people had migrated to the area and started farming. Large-scale wheat cultivation was started which was classified in the aerial photo-interpretation as cultivation with no settlement. In the escarpment about 69 % of the land was under planted forest. The rest was shrub grassland, cultivation and settlement including Kijabe town. In the upland, about 95 % of the area was under forest cover. There was minimal settlement and cultivation (Fig 2).

In 1982 about 80 % of the land in the valley was under settlement and cultivation (Fig 3). This was the period in which most settlers migrated to the area. The land use was changed from shrub grassland into wheat cultivation and large areas were cleared and ploughed with tractors. All trees and bushes were cleared in an attempt to eliminate the breeding sites for Quelia quelia birds which fed on wheat and caused severe

reduction in crop yield. After 1982, there followed three years (1983, 1984 and 1985) of below average annual rainfall of 420 mm, 450 mm and 500 mm respectively that led to total crop failure (Daniel Waciuri Gikonyo, Longonot farmer, personal communication). When the climatic conditions became unfavourable for wheat cultivation in the valley, some people abandoned their farms and migrated to other places. The pastoral Maasai community took advantage and grazed their large herds of livestock in the abandoned farms, causing severe land degradation through accelerated soil erosion by runoff and wind.

In 1990 nearly all the land in the valley was under settlement and cultivation. When wheat cultivation became unprofitable due to frequent droughts, other food crops mainly maize and beans replaced wheat cultivation. People started to settle and cultivate on the slopes of Kijabe hill. Cultivation was also extended to the escarpment though the largest area was under forest cover. In the upland area most of the forest was cleared for settlement and cultivation (Fig 4).

The major LULC changes were noted between 1982 and 1990. In the upland area 54 % of the land was under forest cover in 1970 and by 1990 had reduced to 23 %. In the same period, settlement and farms changed from 3% to 63%. This indicates that planted forest was cleared and the area converted into settlement and farms, a practice that is still going on to date. In the escarpment, planted forest changed from 19% to 15% between 1970 and 1990 respectively. Settlement and farms changed from 14 % - 17 % in the same period. In the Kijabe hill, shrub grassland changed from 83% - 41% while settlement and farms changed from 13% - 59%. In the valley unit, shrub grassland changed from 89% - 3% while settlement and farms changed from 9% - 77% (Table 1).

The greatest increase in the area under settlement and farms was in the valley followed by the upland and Kijabe hill. Initially 1,500 people migrated to the valley from Kiambu district in Central Province between 1970 and 1975 in search for land to settle and cultivate. This led to tremendous change of land use in the valley from grazing to settlement and farms. After 1980, population density increased (Table 2) and most of the planted and indigenous forest in the upland was cleared and land use changed to settlement and farms.

Forest cover change: 1975 - 2000

The time-series analysis of satellite images for 1975 and 2000 indicate more than 50 % reduction in forest cover (Fig 5). The impact of this rapid change in forest cover was accelerated land degradation through soil erosion. It is hypothesized that deforestation has affected hydrology of the escarpment. People in the valley rely on water coming from natural springs in the escarpment. The water supply is not adequate and the shortage is critical in the months of January-March and June-September. This has caused occasional conflicts over water by the communities in the valley. The situation is likely to worsen if the natural springs in the escarpment dry up due to further deforestation and change in land use.

The reduction in forest cover between 1970 and 2000 from the aerial photo and satellite image interpretation was estimated using GIS to be at the rate of 1.5 % and 0.2 % per annum in the upland and the escarpment, respectively (Fig 6). The highest rate of deforestation in the upland was between 1982 and 1990. The extrapolation of the rate of deforestation indicates that by the year 2060 there will be less than 5 % forest cover unless the trend is changed through reforestation programmes (Fig 7).

At the foot of Kijabe hill and the escarpment, cultivated areas with average ground slope of 10 %, are severely eroded as evidenced by gullies that have developed (Fig 8). The lower part with average ground slope of less than 5 % was dominated by rill and inter-rill erosion. The area to the south-west of the main road to Naivasha was largely affected by wind erosion and gully erosion along the water courses. From the aerial photo

upland and escarpment were under forest cover while the valley was under shrub grassland. Active erosion was experienced in the 1980s when large areas in the upland and the escarpment were deforested and opened up for cultivation. This was confirmed by aerial photo interpretation, which indicated high rate of annual deforestation (1.5 %) within that period (Fig 4). Since then, wind erosion has continued to affect many parts of the valley.

GENERAL DISCUSSION

Satellite images and aerial photographs revealed rapid and pervasive deforestation in the upland and the escarpment at Kijabe-Longonot between 1970 and 2000. Within that period 57 % of forest cover was changed to cultivation in the study area, which was estimated to be more than 176 ha. It is predicted that in the next fifty years from 2006, there will be less than 5 % forest cover in the study area unless radical interventions are put in place to reverse the trend of deforestation. The change of land use from forest and grazing to settlement and farms has accelerated land degradation through wind and water erosion. The aerial photographs of 1970 showed only few areas under settlement and farms. The land in the valley was mainly shrub grassland. In 1990 about 80 % of the valley was under settlement and farms. The greatest change in forest cover was in the upland area followed by the escarpment. There was no forest cover in the valley. The average rate of deforestation in the upland area was 1.5 % per annum, which was higher than the global assessment of 0.6 % in the sub-Saharan Africa (FAO, 1997). Deforestation in the upland and escarpment caused high wind velocity in the valley. According to Orare (2001), the mean maximum wind speed in the area is considerably high and may reach up to 20 m/s between June–September and February–March.

CONCLUSION

The conclusion drawn from this study is that:

1. In the four physiographic units of the study area, escarpment covered the largest part but had minimum land use/cover change.
2. The annual rate of deforestation of 1.5 % was higher than the global assessment rate of 0.6 % in sub-Saharan Africa.
3. There has been consistent decrease in forest cover in the upland and escarpment, while cultivated area has continued to increase.

Fig 1. Kijabe- Longonot study area.
Source: Topographic map No 134/3 (Kijabe sheet)
Survey of Kenya, 1975

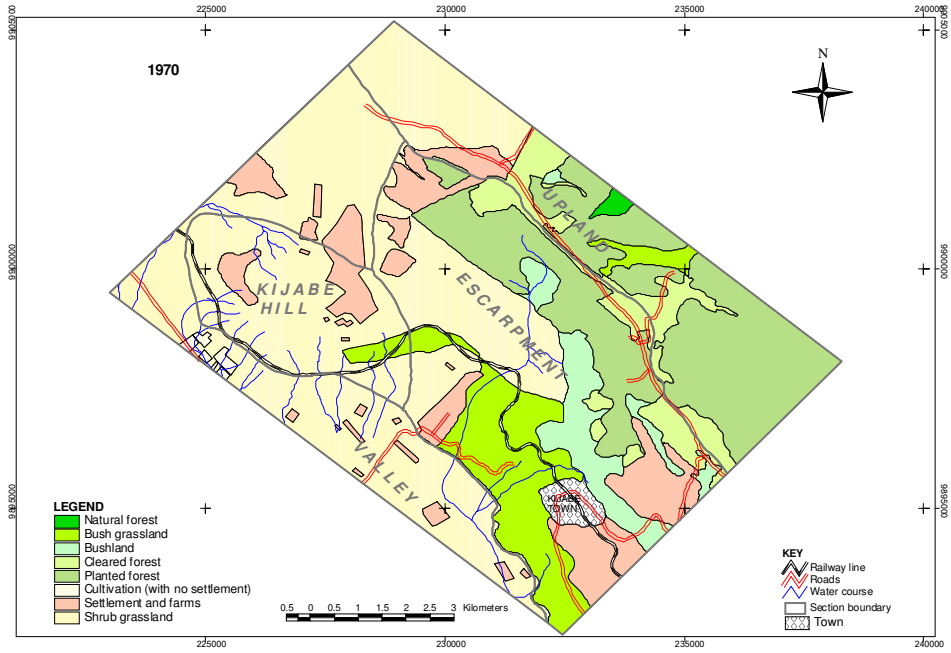

Fig 2: Land use/cover in 1970 at Kijabe-Longonot

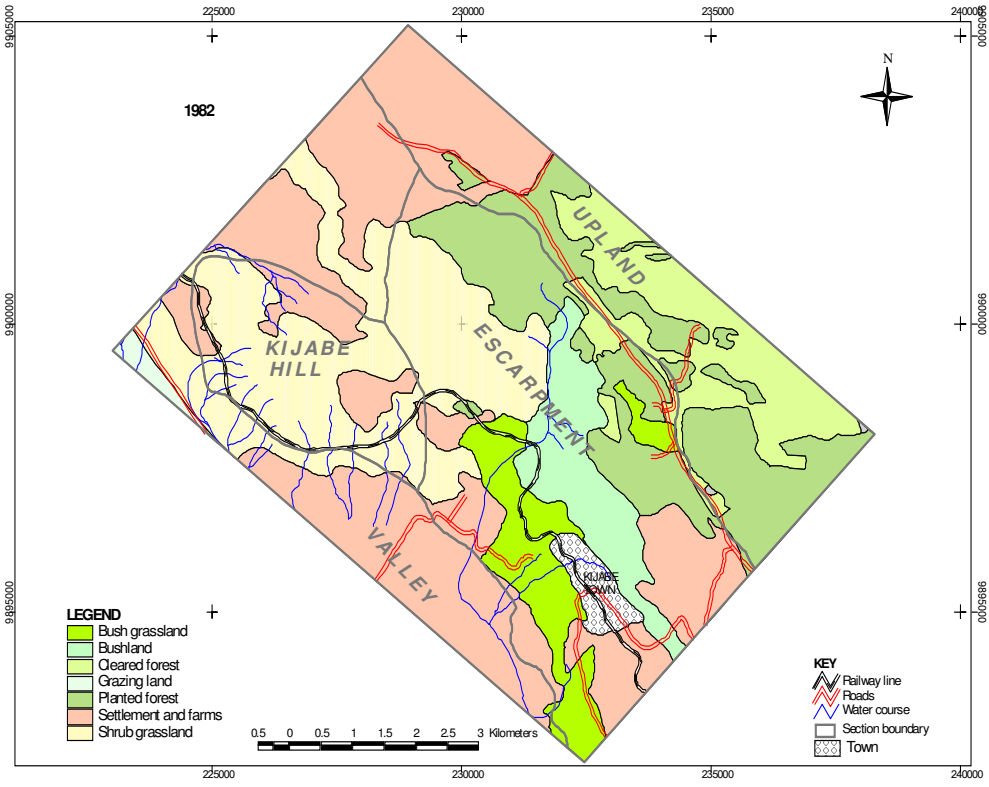

Fig 3: Land use/cover in 1982 at Kijabe-Longonot

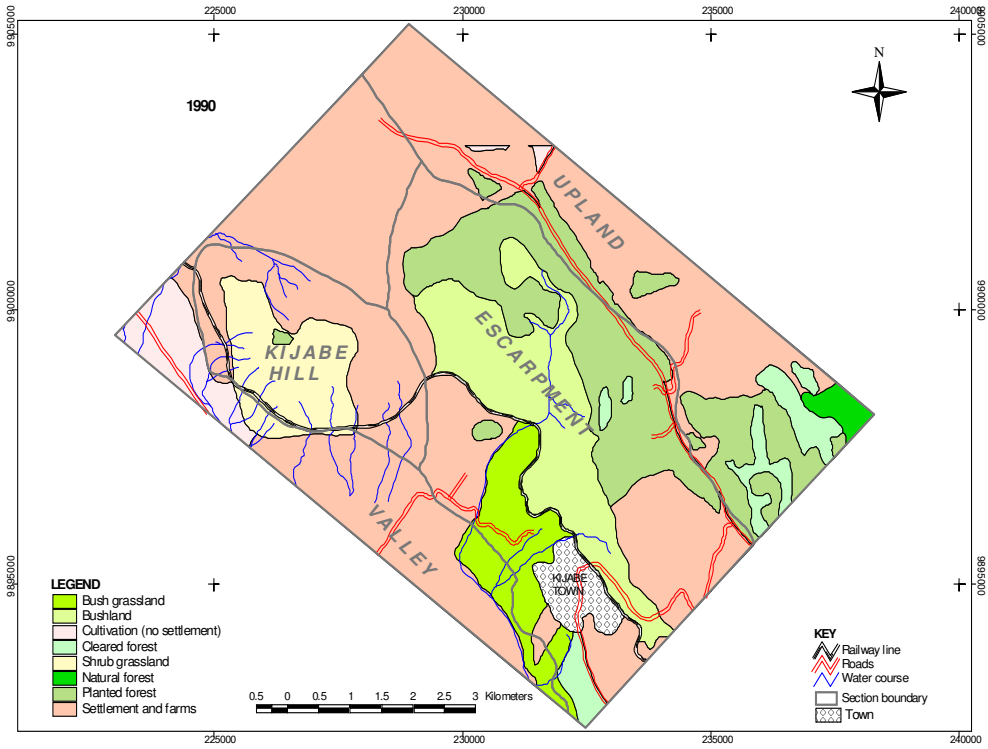

Fig 4: Land use/cover in 1990 at Kijabe-Longonot

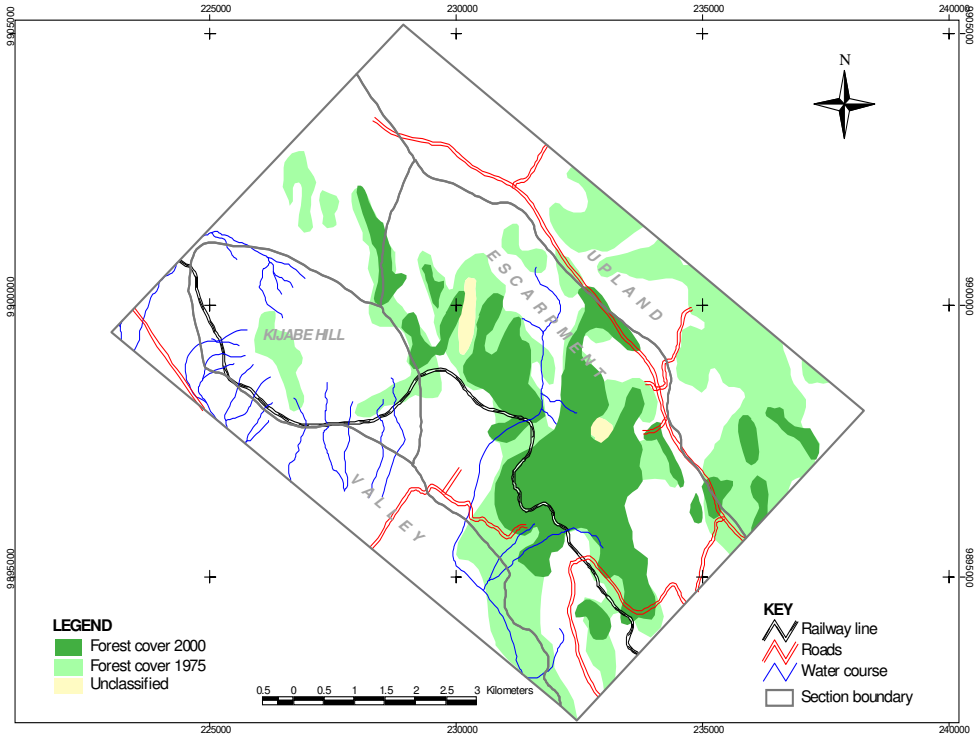

Fig 5: Deforestation between 1975 and 2000 at Kijabe-Longonot

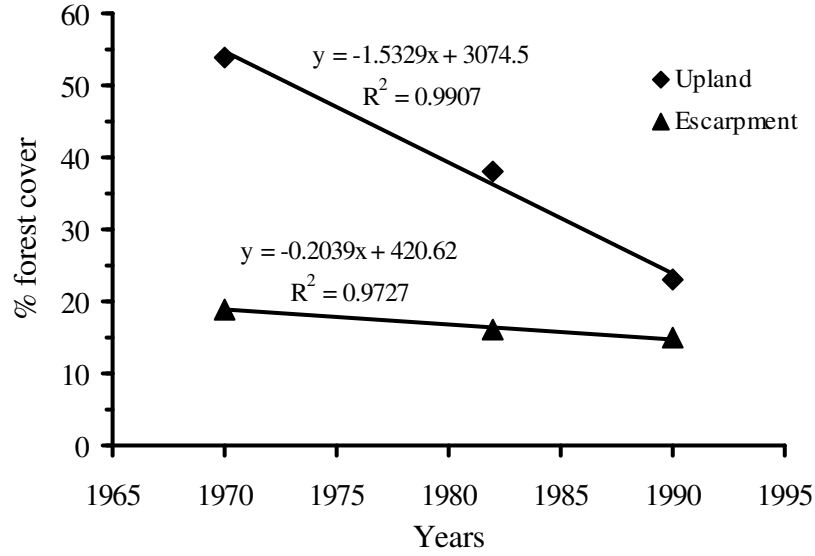

Fig 6: Rate of forest cover reduction in Upland and Escarpment physiographic units at Kijabe-Longonot

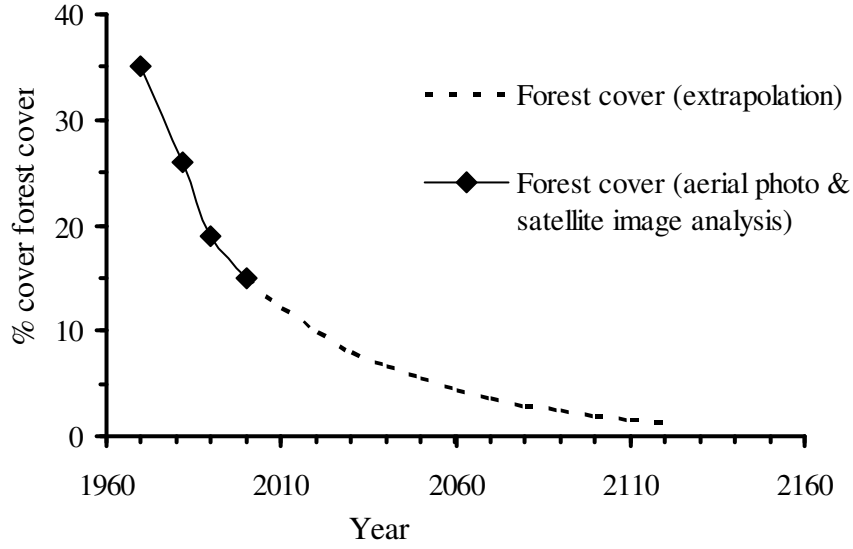

Fig 7: Extrapolation of annual deforestation rate of 1.5 % in the upland and escarpment areas.

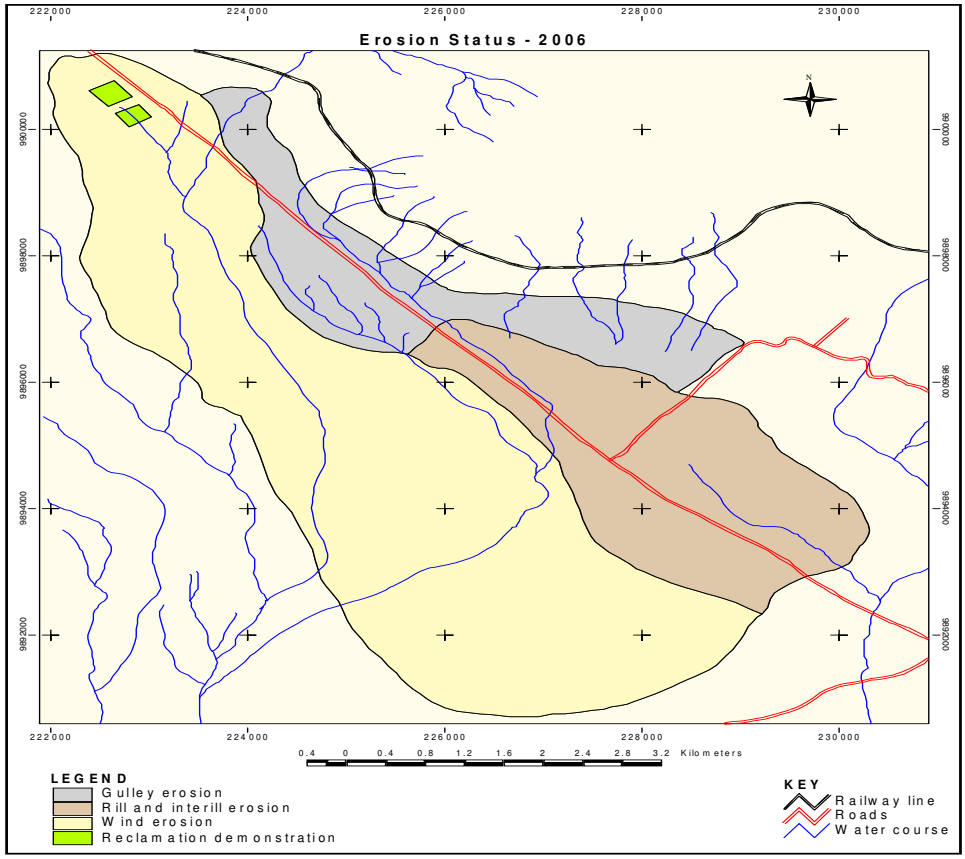

Fig 8: Types and extent of soil erosion in the valley at Longonot

Table 1. Land use/cover classification and percent coverage for Upland, Escarpment, Kijabe hill and the Valley

Classification	Area (ha) and % Land use/cover		
	1970	**1982**	**1990**
Upland	**212 Ha**	**212 Ha**	**212 Ha**
Bush grassland	7 (3 %)	0	0
Bushland	1 (0.4 %)	0	0
Cleared forest	29 (14 %)	78 (37 %)	20 (10 %)
Cultivation (no settlement)	0	0	2 (8 %)
Natural forest	3 (1%)	0	7 (3 %)
Planted forest	114 (54 %)	81 (38 %)	49 (23 %)
Settlement and farms	7 (3 %)	51 (24 %)	134 (63 %)
Shrub grassland	51 (24 %)	0	0
Escarpment	**360 Ha**	**360 Ha**	**360 Ha**
Bush grassland	72 (20 %)	58 (16 %)	34 (9 %)
Bushland	41 (12 %)	35 (10 %)	29 (8 %)
Cleared forest	25 (7 %)	28 (8 %)	10 (3 %)
Cultivation (no settlement)	0	0	0
Natural forest	0	0	0
Planted forest	69 (19 %)	57 (16 %)	53 (15 %)
Settlement and farms	51 (14 %)	56 (16 %)	59 (17 %)
Shrub grassland	82 (23 %)	0	0
Kijabe hill	**110 Ha**	**110 Ha**	**110 Ha**
Bush grassland	0	0	0
Bushland	0	0	0
Cleared forest	0	0	0
Cultivation (no settlement)	0	0	0
Natural forest	0	0	0
Planted forest	0	0	1 (1 %)
Settlement and farms	14 (13 %)	27 (25 %)	64 (59 %)
Shrub grassland	91 (83 %)	83 (75 %)	45 (41 %)
Valley	**203 Ha**	**203 Ha**	**203 Ha**
Bush grassland	0	0	0
Bushland	0	0	0
Cleared forest	0	0	0
Cultivation (no settlement)	3 (2 %)	0	27 (13 %)
Natural forest	0	0	0
Planted forest	0	0	0
Settlement and farms	19 (9 %)	147 (72 %)	157 (77 %)
Shrub grassland	181 (89 %)	50 (24 %)	6 (3 %)

Table 2: Population dynamics between 1969 and 1989 in highland (Kinare), escarpment (Kijabe) and valley (Longonot).

Year and physiographic area	Male	Female	Total	Area km^2	Density (Persons km^{-2})
1969					
Kinare	921	957	1878	150	13
Kijabe	2160	2592	4752	220	22
Longonot	2353	2051	4404	250	18
1979					
Kinare	2636	2505	5141	240	21
Kijabe	3263	3597	6860	290	24
Longonot	3260	3439	6699	280	24
1989					
Kinare	4381	4369	8750	220	40
Kijabe	4835	4818	9653	280	34
Longonot	10643	10816	21459	804	27

Source: GOK, Central Bureau of Statistics, Ministry of Finance and Economic Planning 1969, 1979 and 1989.

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