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Discovering Thoughts, Inventing Future

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A Food Chain with Lethal Prey

By James P. Braselton & Martha L. Abell
Georgia Southern University, United States

Abstract- We form a model of a food chain in the chemist at where the prey species can defend itself against the predator by producing a toxin lethal to the predator. Numerically, we illustrate that if the toxin production by the prey is constant, toxin levels will not vary considerably. On the other hand, if the prey is able to adjust its toxin production based on the density of the predator, toxin levels can vary considerably and periodically. In the context of the biological example we reference, the results indicate that toxic algae blooms might be a regular and periodic occurrence in nature.

Keywords: *chemostat, growth, predator, prey, toxin, toxic algae bloom.*

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A Food Chain with Lethal Prey

James P. Braselton [α] & Martha L. Abell [σ]

Abstract- We form a model of a food chain in the chemist at where the prey species can defend itself against the predator by producing a toxin lethal to the predator. Numerically, we illustrate that if the toxin production by the prey is constant, toxin levels will not vary considerably. On the other hand, if the prey is able to adjust its toxin production based on the density of the predator, toxin levels can vary considerably and periodically. In the context of the biological example we reference, the results indicate that toxic algae blooms might be a regular and periodic occurrence in nature.

Keywords and phrases: chemostat, growth, predator, prey, toxin, toxic algae bloom.

I. Introduction

We consider a basic, resource-based food chain between two organisms of which the chemostat is the standard example. Such models have applications in ecology to model a simple lake and in biotechnology to model the commercial bioreactor. Experimental verification of the match between theory and experiment in the chemostat can be found in Hansen and Hubble, [6]. For a general discussion of competition see Frederickson and Stephanopoulos, [4], and Smith, [27], while a detailed mathematical description of competition in the chemostat may be found in Smith and Waltman, [26].

Inhibitors (including those added to the environment as well as those produced by the competing organisms) in the chemostat have been studied extensively in [3] as well as in [15, 8, 9, 17, 10, 14]. In ecology, inhibitors are often modeling pollutants and studied in the context of detoxification, [14] but in bio-reactors they play the role of controls. Production of, or resistance to, an inhibitor is often accomplished by a genetic modification through a plasmid. Both the production of allelopathic agents (which we will call anti-competitor toxins or toxins) and the resistance to various agents also occur in nature. Several articles of plasmid models in the chemostat include [7, 12, 13, 16, 18, 25, 28].

In nature, there is an interesting relationship between the zooplankton *Karenia brevis* and various zooplankton that feed on it. *Karenia brevis* is responsible for many of the "red tides" or "toxic algae blooms" that occur off the coast of Florida. Initially, these blooms were limited to the Gulf coast of Florida. Now, *Karenia brevis* is found in the Atlantic as well. "Toxic algae blooms" have become more prevalent off the Florida coast causing the extended closure of many beaches to humans and causing harm to marine life because of the toxin produced by *K. brevis*. *K. brevis* produces a type of neurotoxin called a **bevetoxin**, which causes numerous health issues in other marine animals and humans that include but are not limited to gastrointestinal and neurological problems that may be lethal.

Consequently, studying the causes of toxic algae blooms, understanding their underlying causes, and then learning to control or eliminate harmful algae blooms provides significant health and financial benefits to those affected by them. In the case of *Karenia brevis*, some studies provide evidence suggesting that the algae producing the toxin are producing the toxin as a defense against competitors. For example, Sunda et al, [29], conclude that there is biological evidence that shows that *K. brevis*'s brevotoxin production inhibits nearby zooplankton, which promotes the survival of *K. brevis*. Their study further concludes the following.

> Competition experiments reveal that *K. brevis* produces allelopathic compounds, which inhibit the growth of competing phytoplankton and thereby help enable the slow growing species to dominate.

Author α σ: Department of Mathematical Sciences, Georgia Southern University, Statesboro, Georgia 30460-8093, United States.
e-mails: jbraselton@georgiasouthern.edu, martha@georgiasouthern.edu

Braselton and Abell, [1], do a comprehensive numerical study as to when one competitor produces a toxin to defend itself against competitors. Other biological studies indicate that the toxin production is a natural byproduct of *K. brevis*'s metabolism and, consequently, depends on the nutrients that are available to *K. brevis*. Redshaw et al, [21], suggest that introducing a competitor of *K. brevis* such as organisms similar to *Skeletonema grethae*, *Artemia salina*, or *Aiptasia pallida* could be used as a method of biocontrol of *K. brevis* and, consequently, the bevotoxin produced by *K. brevis* that affects numerous organisms. Roth et al, [23, 24], study the effects of introducing algicidal bacteria such as *Cytophaga/Flavobacterium/Bacteroidetes* lethal to *K. brevis* to help control *K. brevis*. Mayali et al, [19], reach similar conclusions as Roth but further conclude that bacterial interactions are "crucial factors that must be taken into consideration in future studies." As temperatures increase, the nutrients available increase and, consequently, the increase in toxin production that has been having severe negative effects on many Florida beaches occur, as has been observed. Refer to Pierce and Henry, [20], for further explanation on this theory. Although the complete understanding of the problem is not a chemostat problem, studying the relationships between different organisms and the cause and effects that they have on others that can be studied in the laboratory is a chemostat problem because relationships between species and nutrient levels can be measured and then plans for addressing the problems caused by the species can be devised based on the science learned in the laboratory. Studies suggested such as these have already been completed in the laboratory. For example, refer to Han et al, [5]. Thus, we believe that following the standards established by these prior studies are appropriate scientific approaches to help us understand and try to solve the problem caused by organisms such as *K. brevis* that cause harmful algae blooms.

II. Background

Following Smith and Waltman, [26], the scaled equations (dimensionless variables) for a basic food chain in the chemostat are

$$\begin{aligned}
\frac{dS}{dt} &= 1 - S - \frac{m_1 S}{a_1 + S} x \\
\frac{dx}{dt} &= x\left[\frac{m_1 S}{a_1 + S} - 1 - \frac{m_2}{a_2 + x} y\right] \\
\frac{dy}{dt} &= y\left[\frac{m_2 x}{a_2 + x} - 1\right] \\
S(0) = S_0 \geq 0,\ x(0) &= x_0 \geq 0,\ y(0) = y_0 \geq 0.
\end{aligned} \tag{1}$$

In system (1), the interpretation is that $S = S(t)$ is the density of the nutrient, the species with density $x = x(t)$ lives on the contents of the nutrient available in the chemostat and the species with density $y = y(t)$ feeds on the the organism with density $x = x(t)$. Further, m_i represents the *maximal growth rate* and the a_i are the *Michaelis-Menton* constants.

The analysis of system (1) begins with letting $\Sigma = 1 - S - x - y$. Then, $\Sigma' + \Sigma = 0$ so $\Sigma = Ce^{-t}$ and, consequently, $\lim_{t\to\infty} \Sigma(t) = 0$. This substitution allows system (1) to be reduced to

$$\begin{aligned}
\frac{dx}{dt} &= x\left[\frac{m_1(1 - x - y)}{1 + a_1 - x - y} - 1 - \frac{m_2}{a_2 + x} y\right] \\
\frac{dy}{dt} &= y\left[\frac{m_2 x}{a_2 + x} - 1\right] \\
x \geq 0,\ y \geq 0, x + y &\leq 1.
\end{aligned} \tag{2}$$

Following Smith and Waltman, [26], define $\lambda_i = \dfrac{a_i}{m_i - 1}$. Let $E_1 = (0, 0)$ and $E_2 = (1 - \lambda_1, 0)$ be the two boundary rest points of system (2). A fundamental result for system (2) is that if $\lambda_1 + \lambda_2 > 1$, then there is no positive solution of (2) which means that under these conditions, E_2 is globally asymptotically stable. On the other hand, if $\lambda_1 + \lambda_2 < 1$, there is a unique interior rest point and E_2 is unstable. In this situation, let $E_c = (x_c, y_c)$ denote the interior rest point. E_c is stable if

$$\frac{y_c}{m_2 {\lambda_2}^2} < \frac{m_1 a_1}{(1 + a_1 - \lambda_2 - y_c)^2}. \tag{3}$$

E_c is unstable if the inequality is reversed so one typically concludes that there are one ore more limit cycles for system (2) in this situation. Although the possibility of multiple limit cycles is not eliminated, the examples that follow indicate that they may be rare or do not exist.

III. Formulation of the Model

We consider two species in the chemostat with densities $x = x(t)$ and $y = y(t)$, respectively. We assume that the species with density x feeds on the nutrient S in the chemostat while the species with density y feeds on the species with density x: y is the predator and x is the prey. The equations are scaled so that the variables are dimensionless.

The model we introduce gives the prey species a mechanism to produce a lethal toxin to the prey that is represented by the $k\dfrac{m_1 S}{a_1 + S}x$ in the P-equation in system (4). We interpret k to be the "effort" that the prey devotes to defending itself against the predator. In this paper we will discuss the cases when k is constant and when k is not but rather depends on the density of the predator with density y.

Taking into consideration the above, the scaled equations for the predator-prey model in the chemostat in which the prey produces a lethal toxins against its predator take the form

$$\begin{aligned}
\frac{dS}{dt} &= 1 - S - \frac{m_1 S}{a_1 + S}x \\
\frac{dx}{dt} &= x\left[\frac{(1-k)m_1 S}{a_1 + S} - 1 - \frac{m_2}{a_2 + x}y\right] \\
\frac{dy}{dt} &= y\left[\frac{m_2}{a_2 + x}x - 1 - \gamma P\right] \\
\frac{dP}{dt} &= k\frac{m_1 S}{a_1 + S}x - P \\
S(0) = S_0 \geq 0,\ x(0) &= x_0 \geq 0,\ y(0) = y_0 \geq 0.
\end{aligned} \tag{4}$$

The following analysis considers two situations. For simplicity, we first assume that k is constant. Then, we consider the more likely possibility that the prey's defense against the predator depends on the density of the predator.

Hsu and Waltman, [10] or [11], study the case when x and y are competitors. Remarkably, the analysis of system (4) can be carried out in a similar manner as to the systems that arise when the species with density $x = x(t)$ and the species with density $y = y(t)$ are competitors. To see the similarities, first let $\Sigma = S + x + y + P$. Then, $\Sigma' + \Sigma = 1 - \gamma y P \leq 1$ which means $\limsup_{t\to\infty} \Sigma(t) \leq 1$. Each component of system (4) is non-negative so system (4) is dissipative and consequently has a compact, global attractor.

IV. K Constant

If k is constant, to simplify system (4), let $z = S + \dfrac{1}{k}P$. Then, $z' + z = 1$ and the change of variables results in the system

$$\begin{aligned}
\frac{dz}{dt} &= 1 - z \\
\frac{dS}{dt} &= 1 - S - \frac{m_1 S}{a_1 + S} x \\
\frac{dx}{dt} &= x\left[\frac{(1-k)m_1 S}{a_1 + S} - 1 - \frac{m_2}{a_2 + x} y\right] \\
\frac{dy}{dt} &= y\left[\frac{m_2}{a_2 + x} x - 1 - \gamma k(z - S)\right].
\end{aligned} \tag{5}$$

Solving for $z(t)$, we find $z(t) = 1 + Ce^{-t}$ so that $\lim_{t\to\infty} z(t) = 1$ and as $t \to \infty$, $P = k(1 - S)$. Thus, (5) can be viewed as an asymptotic system with limiting system

$$\begin{aligned}
\frac{dS}{dt} &= 1 - S - \frac{m_1 S}{a_1 + S} x \\
\frac{dx}{dt} &= x\left[\frac{(1-k)m_1 S}{a_1 + S} - 1 - \frac{m_2}{a_2 + x} y\right] \\
\frac{dy}{dt} &= y\left[\frac{m_2}{a_2 + x} x - 1 - \gamma k(1 - S)\right].
\end{aligned} \tag{6}$$

As before, the system is dissipative, the positive cone is positively invariant, and $x = 0$ and $y = 0$ are invariant sets. Once we analyze system (6), because of the works of Thieme, [31] and [30], the results obtained for system (6) will apply to system (5) and subsequently system (4). Observe that if $m_1 < \frac{1}{1-k}$, $\lim_{t\to\infty} x(t) = 0$. Similarly, if $m_2 < 1$, $\lim_{t\to\infty} y(t) = 0$. Thus, we assume that $m_1 > \frac{1}{1-k}$ and that $m_2 > 1$.

4.1. **The Boundary Rest Points.** To help us classify the rest points, we first observe that the Jacobian of system (6) is

$$\mathbf{J} = \begin{pmatrix} -\frac{a_1 m_1 x}{(a_1+S)^2} - 1 & -\frac{m_1 S}{a_1+S} & 0 \\ -\frac{a_1(k-1)m_1 x}{(a_1+S)^2} & -\frac{a_1+(k-1)m_1 S+S}{a_1+S} - \frac{a_2 m_2 y}{(a_2+x)^2} & -\frac{m_2 x}{a_2+x} \\ ky\gamma & \frac{a_2 m_2 y}{(a_2+x)^2} & \frac{m_2 x}{a_2+x} + k(S-1)\gamma - 1 \end{pmatrix}. \tag{7}$$

If $x = 0$ it follows that (6) has boundary rest point $E_0 = (S_0, x_0, y_0) = (1, 0, 0)$. Evaluated at E_0, the Jacobian is

$$\mathbf{J}(E_0) = \begin{pmatrix} -1 & -\frac{m_1}{a_1+1} & 0 \\ 0 & \frac{m_1 - km_1}{a_1+1} - 1 & 0 \\ 0 & 0 & -1 \end{pmatrix}$$

with eigenvalues $\lambda_{1,2} = -1$ and $\lambda_3 = \frac{(1-k)m_1}{a_1+1} - 1$. For the problem to be meaningful, E_0 must be unstable. Therefore, to guarantee that E_0 is unstable we must further assume that

$$\frac{(1-k)m_1}{a_1+1} > 1 \qquad \text{or} \qquad \frac{m_1}{a_1+1} > \frac{1}{1-k}, \tag{8}$$

Observe that this assumption implies that $m_1 > \frac{1}{1-k}$. Thus, with our assumptions, E_0 is always unstable.

If $y = 0$, we obtain the restpoint, $E_y = (S_y, x_y, 0)$, where

$$S_y = \frac{a_1}{(1-k)m_1 - 1} \qquad \text{and} \qquad x_y = 1 - k - \frac{(1-k)a_1}{(1-k)m_1 - 1}.$$

At E_y, the Jacobian is

$$\mathbf{J}(E_y) = \begin{pmatrix} \frac{((k-1)m_1+1)^2+a_1}{a_1(k-1)m_1} & \frac{1}{k-1} & 0 \\ \frac{((k-1)m_1+1)(a_1+(k-1)m_1+1)}{a_1 m_1} & 0 & -\frac{(k-1)(a_1+(k-1)m_1+1)m_2}{a_1(k-1)-(a_2-k+1)((k-1)m_1+1)} \\ 0 & 0 & a_1 (+ (k-1)m_1 + 1)\left(\frac{(k-1)m_2}{a_1(k-1)-(a_2-k+1)((k-1)m_1+1)} - \frac{k\gamma}{(k-1)m_1+1}\right) - 1 \end{pmatrix}.$$

Table 1: The stability of the rest points using $m_1 = 2.0$, $a_1 = 0.5$, $m_2 = 1.5$, $a_2 = 0.25$, $k = 0.1$, and $\gamma = 0.5$.

Rest Point	Eigenvalues of Jacobian evaluated at rest point	Classification
$E_0 = (1, 0, 0)$	-1, -1, 0.2	Unstable
$E_y = (0.625, 0.3375, 0)$	-1, -0.7299, -0.157	Locally stable

The eigenvalues of $\mathbf{J}(E_y)$ are $\lambda_1 = -1$,

$$\lambda_2 = -\frac{(1-(1-k)m_1)(a_1+1-(1-k)m_1)}{a_1(1-k)m_1}$$

and

$$\lambda_3 = \frac{1}{((k-1)m_1+1)(a_1(k-1)-(a_2-k+1)((k-1)m_1+1))}\Big[-a_1^2\gamma(1-k)k+$$

$$a_1((1-k)m_1-1)\left(-k((a_2+2)\gamma+m_2-1)+2\gamma k^2+m_2-1\right)+$$

$$((k-1)m_1+1)^2(a_2\gamma k+a_2-(k-1)(\gamma k-m_2+1))\Big].$$

Because we are assuming that $m_1 > \frac{m_1}{a_1+1} > \frac{1}{1-k}$ and $m_1(1-k)-a_1-1 > 0$, $\lambda_2 < 0$. Observe that with our assumptions regarding the parameter values, the denominator of λ_3 is always negative. The numerator of λ_3 will be negative so that $\lambda_3 > 0$ and unstable if

$$m_2 > \frac{(a_1(k-1)-(a_2-k+1)((k-1)m_1+1))((a_1+1)\gamma k+(k-1)m_1(\gamma k+1)+1)}{(k-1)((k-1)m_1+1)(a_1+(k-1)m_1+1)}$$

and positive otherwise. Thus, we see that λ_3 will be positive for a wide range of parameter values. Because the focus of our problem is to see if the species with density $y(t)$ can control the density of the species with density $x(t)$, we will choose parameter values so that λ_3 has positive real part so that E_y is unstable.

4.2. **The Interior Rest Points.** If interior rest points of system (6) exist, they take the form $E_c = (S_c, x_c, y_c)$ where

$$x_c = a_2\left(\frac{m_2}{\gamma k(S_c-1)+m_2-1} - 1\right) \quad \text{and} \quad y_c = -\frac{a_2(a_1+(k-1)m_1S_c+S_c)}{(a_1+S_c)(\gamma k(S_c-1)+m_2-1)}. \tag{9}$$

S_c satisfies the cubic

$$k\gamma {S_c}^3+[\gamma k(a_1-a_2m_1-2)+m_2-1]{S_c}^2+[a_1(-2\gamma k+m_2-1)+a_2m_1(\gamma k+1)+\gamma k-m_2+1]$$
$$S_c+a_1(\gamma k-m_2+1) = 0. \tag{10}$$

As indicated in the examples that follow, the system is sensitive to parameter values. To see so, we fix all but one parameter value, then allow the remaining value to change. The example illustrates sensitivity to constant k. We obtained the same results when studying sensitivity to γ, but chose to illustrate sensitivity to constant k here as we consider nonconstant k in the next section.

Example 1. For our first example, we choose $m_1 = 2.0$, $a_1 = 0.5$, $m_2 = 1.5$, $a_2 = 0.25$, $k = 0.1$, and $\gamma = 0.5$. These parameter values result in the rest points $E_0 = (1, 0, 0)$ and $E_y = (0.625, 0.3375, 0)$. There are no interior rest points. The eigenvalues of the Jacobian evaluated at each rest point and their local stability are illustrated in Table 1.

Parametric plots of x-vs-y are shown in Figure 1. In the figure, observe that the stability of E_x appears to be global rather than local.

Depending on the parameter values, an interior rest point can be stable.

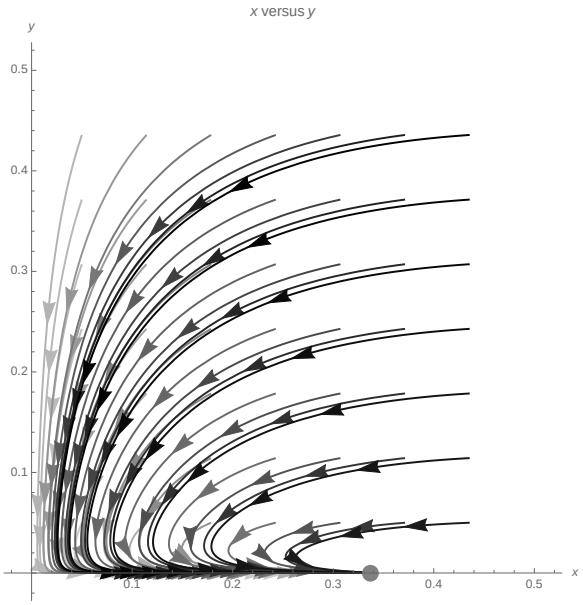

Figure 1: Notice that all nontrivial solutions appear to approach E_y.

Table 2: The stability of the rest points using $m_1 = 1.121$, $a_1 = 0.05$, $m_2 = 1.5$, $a_2 = 0.25$, $k = 0.01$, and $\gamma = 3.25$.

Rest Point	Eigenvalues of Jacobian evaluated at rest point	Classification
$E_0 = (1, 0, 0)$	-1, -1, 0.0569	Unstable
$E_y = (0.455, 0.539, 0)$	-1, -0.11829, 0.007	Unstable
$E_c = (0.466, 0.5269, 0.0013)$	-1.0, -0.1011, -0.008	Locally stable

Example 2. To illustrate a locally stable interior rest point, we choose $m_1 = 1.121$, $a_1 = 0.05$, $m_2 = 1.5$, $a_2 = 0.25$, $k = 0.01$, and $\gamma = 3.25$. These parameter values result in the rest points $E_0 = (1, 0, 0)$, $E_y = 0.455, 0.539, 0)$, and $E_c = (0.466, 0.5269, 0.0013)$. The eigenvalues of the Jacobian evaluated at each rest point and their local stability are illustrated in Table 2.

Parametric plots of x-vs-y are shown in Figure 2. In the figure, observe that the stability of E_c appears to be global rather than local.

Our next example illustrates sensitivity to parameter values. Because we will consider nonconstant k next, we illustrate sensitivity to k here. We obtained similar results with sensitivity to γ or the other parameters.

Example 3. We begin with $m_1 = 2.0$, $a_1 = 0.5$, $m_2 = 5.5$, $a_2 = .25$, $k = 0.15$ and $\gamma = 0.5$. For these parameter values we obtain $E_0 = (1, 0, 0)$, $E_y = (0.714, 0.243, 0)$, and $E_c = (0.927, 0.0559, 0.00581)$. The eigenvalues of the Jacobian evaluated at each rest point and their local stability are illustrated in Table 3. We classify E_c as a stable spiral. In Figure 3 observe that it appears that all nontrivial solutions approach E_c.

Next, we use nearly the same parameter values except for changing k from $k = 0.15$ to $k = 0.1$.

With these parameter values, E_0 and E_y are unstable, while E_c is classified as an unstable spiral. See Figure 4. In the figure, observe that all nontrivial solutions appear to

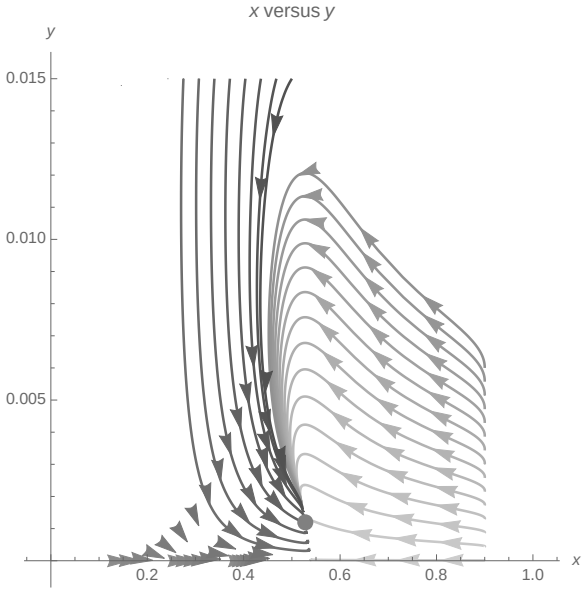

Figure 2: All nontrivial solutions appear to approach E_c.

Table 3: The stability of the rest points using $m_1 = 2.0$, $a_1 = 0.5$, $m_2 = 5.5$, $a_2 = .25$, $k = 0.15$ and $\gamma = 0.5$.

Rest Point	Eigenvalues of Jacobian evaluated at rest point	Classification
$E_0 = (1, 0, 0)$	$-1, -1, 0.133$	Unstable
$E_y = (0.714, 0.243, 0)$	$-1, -0.1647, 1.68872$	Unstable
$E_c = (0.927, 0.00581, 0.0559)$	$-1.0, -0.00443 \pm 0.296i$	Stable spiral

Table 4: The stability of the rest points using $m_1 = 2.0$, $a_1 = 0.5$, $m_2 = 5.5$, $a_2 = .25$, $k = 0.1$ and $\gamma = 0.5$.

Rest Point	Eigenvalues of Jacobian evaluated at rest point	Classification
$E_0 = (1, 0, 0)$	$-1, -1, 0.2$	Unstable
$E_y = (0.625, 0.3375, 0)$	$-1, -0.2667, 2.14$	Unstable
$E_c = (0.927, 0.0559, 0.009425)$	$-1.0, 0.00151 \pm 0.3773i$	Unstable spiral

approach a unique limit cycle. In (a), we illustrate the periodicity of x (in black) and y (in gray) in the limit cycle. On the other hand, (b) illustrates that all nontrivial solutions appear to approach a unique limit cycle while (c) illustrates a possible unique limit cycle. It is important to remember that although the calculations indicate the existence of a limit cycle, they do not establish its uniqueness, which might be an interesting topic in a future study.

The sensitivity to the parameter values is striking. Changing the value of k from $k = 0.1$ to $k = .1127$ and keeping the remaining parameter values the same yields the results show in Table 5. In Table 5, notice that the real part of the eigenvalues for the Jacobian of E_c are "small"–and might be interpreted to be zero.

However, E_c is a stable spiral as illustrated in Figure 5.

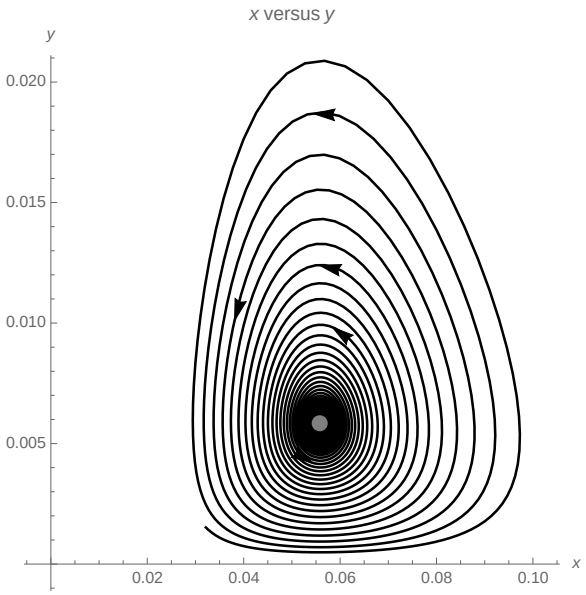

Figure 3: All nontrivial solutions appear to approach E_c.

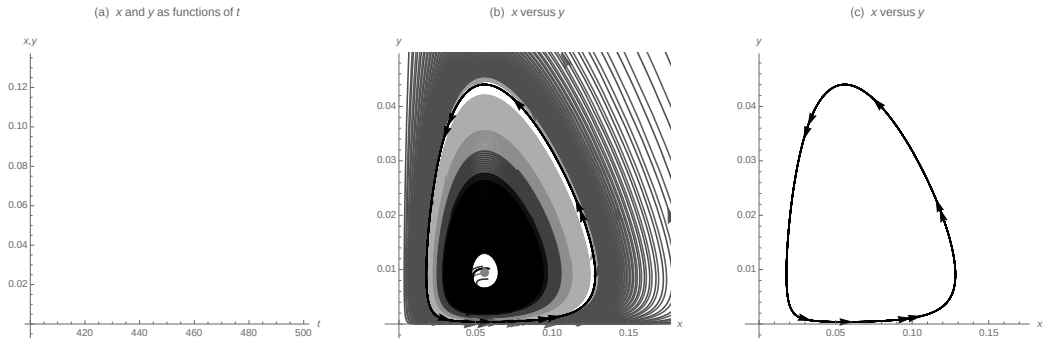

Figure 4: All nontrivial solutions appear to approach a unique limit cycle.

Table 5: The stability of the rest points using $m_1 = 2.0$, $a_1 = 0.5$, $m_2 = 5.5$, $a_2 = .25$, $k = 0.1127$ and $\gamma = 0.5$.

Rest Point	**Eigenvalues of Jacobian evaluated at rest point**	**Classification**
$E_0 = (1, 0, 0)$	-1, -1, 0.183	Unstable
$E_y = (0.645, 0.3146, 0)$	-1, -0.2379, 2.04	Unstable
$E_c = (0.927, 0.0559, 0.00851)$	-1.0, $-5.6512 \times 10^{-6} \pm 0.3584i$	Stable spiral

Alternatively, changing the k-value to $k = 0.1126$ and keeping the remaining parameter values the same yields quite different results than using $k = 0.1127$. See Table 6

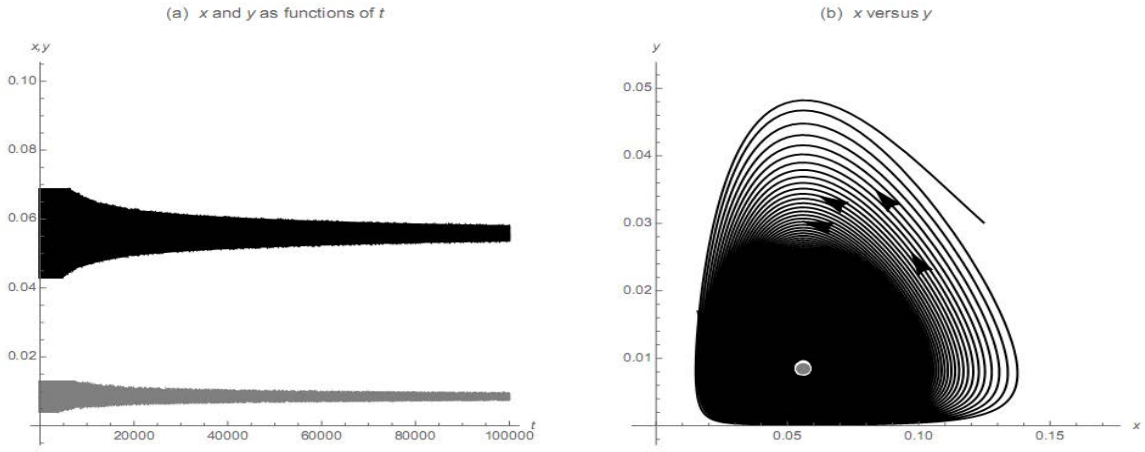

Figure 5: All nontrivial solutions appear to approach E_c.

Table 6: The stability of the rest points using $m_1 = 2.0$, $a_1 = 0.5$, $m_2 = 5.5$, $a_2 = .25$, $k = 0.1126$ and $\gamma = 0.5$.

Rest Point	Eigenvalues of Jacobian evaluated at rest point	Classification
$E_0 = (1, 0, 0)$	-1, -1, 0.183	Unstable
$E_y = (0.645, 0.3147, 0)$	-1, -0.2399, 2.045	Unstable
$E_c = (0.927, 0.0558, 0.00851)$	-1.0, $6.2822 \times 10^{-6} \pm 0.3586i$	Unstable spiral

In Table 6, notice that the real part of the eigenvalues for the Jacobian of E_c are "small"–and might be interpreted to be zero. However, E_c is an unstable spiral as illustrated in Figure 6.

Our numerical results seem to indicate that when the parameter values are chosen so that the eigenvalues of the Jacobian evaluated at E_c are "close" to zero, numerical error and precision are important. When the real part of an eigenvalue of the Jacobian evaluate at E_c is positive, the result appears to be convergence of solutions to a unique limit cycle. However, when the real part is "small" it may take computationally and time intense numerical work to illustrate the limit cycle. The results indicate that the convergence to the limit cycle will take larger t-values. In our cases we carried t to $t = 1000000$ (remember that the system is dimensionless so these t-values do not represent days, minutes, years, and so on). As the real part of the eigenvalue corresponding to E_c becomes smaller but remains positive, the limit cycle about E_c will become smaller and smaller. Once the parameter values are chosen so that the real part of the eigenvalues corresponding to E_c are negative, it appears to take larger (or longer) t-values to observe the convergence of the solutions to E_c.

We were not able to find multiple limit cycles nor prove that they do not exist.

V. Nonconstant K

We believe that studying the case when k is nonconstant is important because studies such as those done by Roth et al, [23, 24] indicate that dinoflagellates such as *K. brevis* may be able to detect (and probably even develop defenses) against organisms threatening it. Mayali and Doucette, [19], conclude that situations such as these indicate that "bacterial

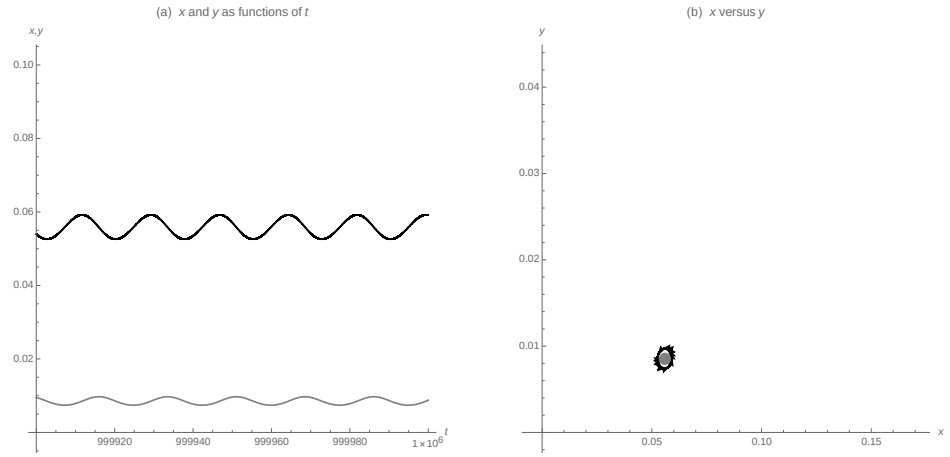

Figure 6: All nontrivial solutions appear to approach a unique limit cycle about E_c.

interactions are crucial factors that must be taken into consideration in future studies." Situations such as these indicate that the parameter k is not constant.

If we assume that k is not constant but rather a function of x and y (or even t), In the case that k is not constant we consider the functions $k = k(x, y)$ used by Braselton and Waltman, [2],

$$k = k_y(x, y) = \frac{\alpha y}{\beta + x + y} \quad \text{or} \quad k = k_x(x, y) = \frac{\alpha x}{\beta + x + y}. \tag{11}$$

These two choices represent quite different strategies. For k_x, if x is large the species with density $x = x(t)$ devotes more of its resources to producing the toxin, which may not be a sensible assumption in a predator-prey relationship when the species with density $x = x(t)$ is the prey. If the species with density $y = y(t)$ is not present (and β is small), toxin production is essentially constant, which was studied in the previous examples. Thus, we will not further discuss the $k = k_x$ strategy. In a predator-prey relationship, the $k = k_x$ strategy does not seem sensible. If the prey is able to detect its predator, why would it continue to increase its toxin production at the expense of its own growth rate once the predator is eliminated?

On the other hand, if y is large the k_y strategy causes the species with density $x = x(t)$ to increase its toxin production. The form of system (4) remains the same but now k is no longer assumed to be constant. System (12) cannot be reduced from four equations to three as we did when we assumed that k was constant as with system (4).

$$\begin{aligned}
\frac{dS}{dt} &= 1 - S - \frac{m_1 S}{a_1 + S} x \\
\frac{dx}{dt} &= x\left[\frac{(1 - k(x, y))m_1 S}{a_1 + S} - 1 - \frac{m_2}{a_2 + x} y\right] \\
\frac{dy}{dt} &= y\left[\frac{m_2}{a_2 + x} x - 1 - \gamma P\right] \\
\frac{dP}{dt} &= k(x, y)\frac{m_1 S}{a_1 + S} x - P \\
S(0) &= S_0 \geq 0,\ x(0) = x_0 \geq 0,\ y(0) = y_0 \geq 0.
\end{aligned} \tag{12}$$

Table 7: The stability of the rest points (S, x, y, P) using $m_1 = 2.0$, $a_1 = 0.5$, $m_2 = 5.5$, $a_2 = .25$, $\gamma = 0.5$, and $k = k_y$ with $\alpha = 1.0$ and $\beta = 0.01$.

Rest Point	Eigenvalues of Jacobian evaluated at rest point	Classification
$E_0 = (1, 0, 0, 0)$	$-1, -1, 0.333, 0$	Unstable
$E_y = (0.5, 0.5, 0, 0)$	$-1, -0.5, 2.67, 0$	Unstable
$E_c = (0.927, 0.056, 0.00844, 0.008245)$	$-1.0044, 0.0027754, 0.0565 \pm 0.4874$	Unstable spiral

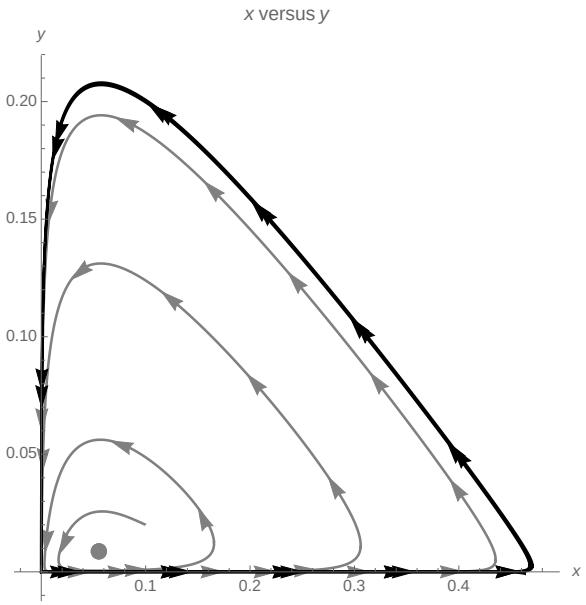

Figure 7: All nontrivial solutions appear to approach a unique limit cycle about E_c.

Example 4.

allocated inhibitor production, with the exception of the k-value we use the same values as those used previously: $m_1 = 2.0$, $a_1 = 0.5$, $m_2 = 5.5$, $a_2 = .25$, and $\gamma = 0.5$. Now allow $k = k_y$ and choose $\alpha = 1.0$ and $\beta = 0.01$.

In Figure 7, we parametrically plot a typical solution of the system for these parameter values as a function of x-vs-y. The long term plot is shown in black. Observe that all non-trivial solutions to the system appear to approach a unique limit cycle about E_c.

On the other hand, in Figure 8, we illustrate the limit cycle with long term plots of x, y, and P as functions of t.

Next in Figure 9 we plot P as a function of t using the k-values used in the previous examples.

Observe the striking difference between Figure 8 (c) and Figure 9. Constant toxin production appears to stabilize the system. On the other hand, when the prey is able to adjust its toxin production based on the density of the predator, "extreme" periodic limit cycles occur.

In the context of our example of *K. brevis* and its potential toxin production against predators, these numerical results indicate that if the prey is able to adjust its toxin production based on the density of the predator, the density of the toxin will be periodic

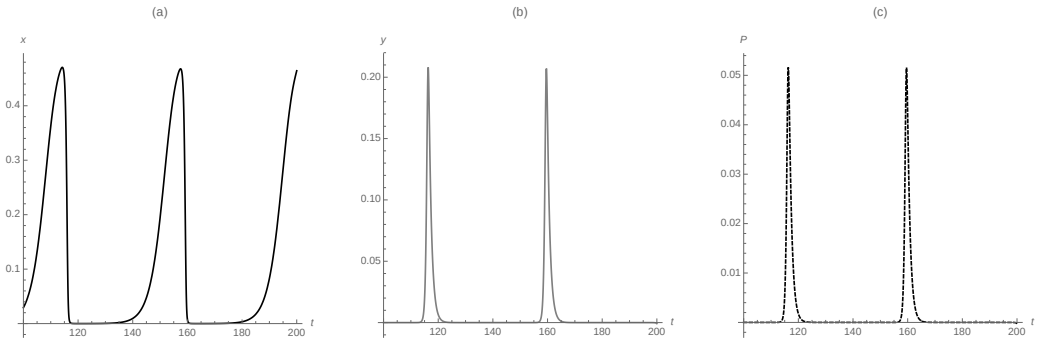

Figure 8: (a) x (prey) as a function of t, (b) y (predator) as a function of t, (c) P (toxin) as a function of t.

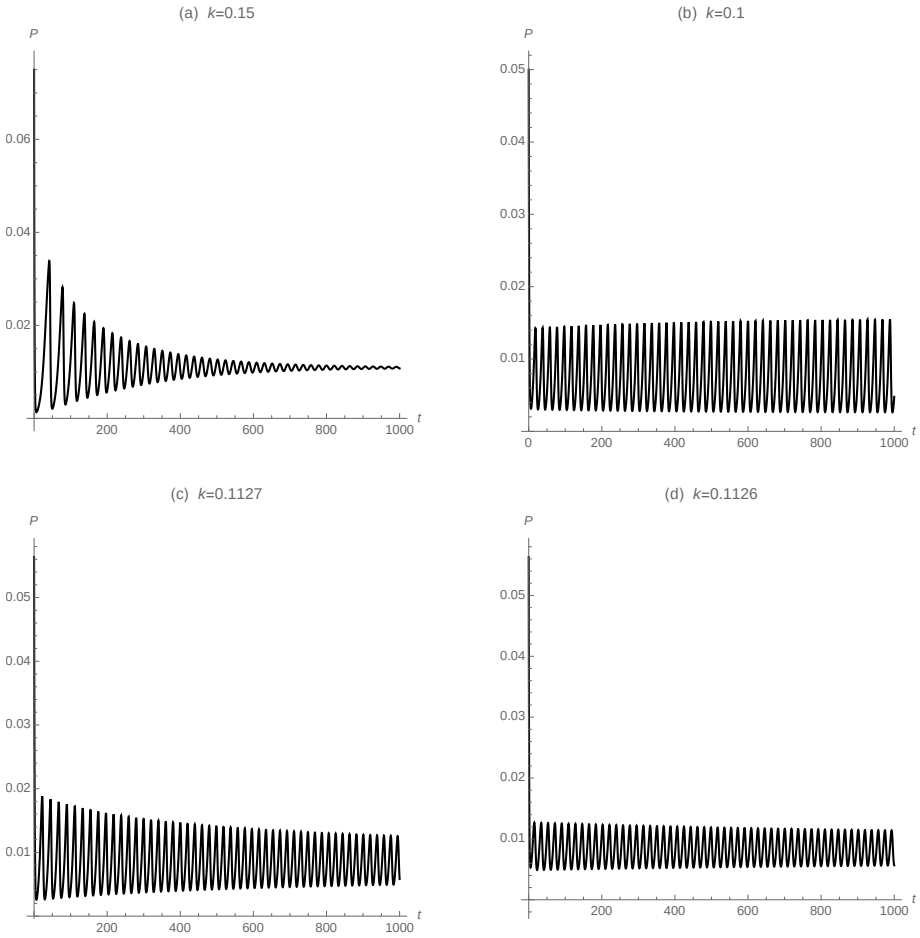

Figure 9: (a) $k = 0.15$, (b) $k = 0.1$, (c) $k = 0.1127$, (d) $k = 0.1126$.

and more extreme than when the prey produces toxin at a constant level. Thus, if this is a model that most accurately describes the *K. brevis* algae blooms, the algae blooms should be expected to occur periodically and be extreme rather than be a persistent menace (Figure 9).

VI. Conclusion

We have numerically studied a simple food chain in the chemostat where the prey species is given a defense against the predator by being able to produce a toxin that is lethal to the predator. We have considered the situation when the prey's defense is constant as well as when the prey's defense depends on the density of the predator. The numerical results indicate that constant toxin production lead to predictable, although mildly periodic, toxin levels. On the other hand, when the prey can adjust its toxin production based on its ability to detect the predator, extremes can occur. In the context of the biological example considered here, the results indicate that it is possible that harmful algae blooms should be periodically expected and expected to be extreme.

Species evolve as do predator-prey relationships. Waltman et al, [32], study a predator-prey relationship where the predator and prey evolve. The prey evolves to produce a toxin more lethal against the predator while the predator evolves so that it is immune or less harmed by the toxin produced by the prey species. We have not considered the possibility of evolving predators or prey in this theoretical study but hope to do so in the future.

It is important to observe that Roth et al, [23, 24], provide evidence that *K. brevis* may be able to develop resistance to algicidal bacteria. We have not considered that possibility here but hope to do so in a future study.

Computational Notes

The graphics and computations in this paper were carried out with *Mathematica 12.0*, [22]. You can receive a copy of the *Mathematica* notebooks used here by sending a request to `jbraselton@georgiasouthern.edu`.

References Références Referencias

1. James P. Braselton and Martha L. Abell. Competition in the chemostat with an undesirable lethal competitor. *Mathematical Biosciences,* 310:136 -147, 2019.
2. James P. Braselton and Paul Waltman. A competition model with dynamically allocated inhibitor production. *Mathematical Biosciences,* 173:55-84, 2001.
3. Lin Chao and Bruce R. Levin. Structured habitats and the evolution of anticompetitor toxins in bacteria. *Proc. Nat. Acad. Sci. USA,* 78(10):6324-6328, 1981.
4. A. G. Fredrickson and G. Stephanopoulos. Microbial competition. Science, 213(4511):972-979, 1981.
5. Myungsoo Han, Haeok Lee, Donald M. Anderson, and Baikho Kim. Paralytic shellfish toxin production by the dinoagellate alexandrium pacificum (chinhae bay, korea) in axenic, nutrient-limited chemostat cultures and nutrient-enriched batch cultures. *Marine Pollution Bulletin*, 104(1):34-43, 2016.
6. S. R. Hansen and S. P. Hubbell. Single-nutrient microbial competition: qualitative agreement between experimental and theoretically forecast outcomes. *Science*, 207(4438):1491-1493, 1980.
7. S. B. Hsu, Ting-Kung Luo, and Paul Waltman. Competition between plasmid-bearing and plasmid-free organisms in a chemostat with an inhibitor. *Journal of Mathematical Biology*, 34(2):225-238, Jan 1995.
8. S. B. Hsu and Paul Waltman. Competition in the chemostat when one competitor produces a toxin. Japan Journal of Industrial and Applied Mathematics, 15(3):471{490, 1998.
9. S.B. Hsu, Yen-Sheng Li, and Paul Waltman. Competition in the presence of a lethal external inhibitor. *Mathematical Biosciences*, 167(2):177{199, 2000.
10. S.B. Hsu and Paul Waltman. Analysis of a model of two competitors in a chemostat with an external inhibitor. *SIAM J. Appl. Math,* 52(2):528-540, 1992.
11. S.B. Hsu and Paul Waltman. A survey of mathematical models of competition with an inhibitor. *Mathematical Biosciences,* 187:53-91, 2004.
12. Sze-Bi Hsu and Paul Waltman. Competition between plasmid-bearing and plasmid-free organisms in selective media. *Chemical Engineering Science*, 52(1):23-35, 1997.
13. Sze-Bi Hsu, Paul Waltman, and Gail S. K. Wolkowicz. Global analysis of a model of plasmid-bearing, plasmid-free competition in a chemostat. *Journal of Mathematical Biology*, 32(7):731-742, Aug 1994.
14. Richard E. Lenski and S E Hattingh. Coexistence of two competitors on one resource and one inhibitor: a chemostat model based on bacteria and antibiotics. *Journal of theoretical biology*, 122 1:83{93, 1986.
15. B.R. Levin. Frequency-dependent selection in bacterial populations. *Philosophical Transactions of the Royal Society of London B: Biological Sciences,* 319(1196):459{472, 1988.
16. Zhiqi Lu and K.P. Hadeler. Model of plasmid-bearing, plasmid-free competition in the chemostat with nutrient recycling and an inhibitor. *Mathematical Biosciences*, 148(2):147-159, 1998.
17. Ting-Kung Luo and Sze-Bi Hsu. Global analysis of a model of plasmid-bearing, plasmid-free competition in a chemostat with inhibitions. *Journal of Mathematical Biology*, 34(1):41-76, Jan 1995.
18. Catherine A. Macken, Simon A. Levin, and Roland Waldst□atter. The dynamics of bacteriaplasmid systems. *Journal of Mathematical Biology*, 32(2):123{145, Jan 1994.
19. Xavier Mayali and Gregory J Doucette. Microbial community interactions and population dynamics of an algicidal bacterium active against karenia brevis (dinophyceae). *Harmful Algae*, 1(3):277-293, 2002.
20. Richard Pierce and Michael Henry. Harmful algal toxins of the orida red tide (karenia brevis): Natural chemical stressors in south orida coastal ecosystems. *Ecotoxicology (London, England)*, 17:623-31, 09 2008.
21. Clare H. Redshaw, Denise A. Sutter, Krista Lim-Hing, Melanie L. Heckman, Stina L. Jakobsson, Jerome Naar, and Julia Kubanek. Tracking losses of brevetoxins on exposure to phytoplankton competitors: Ecological impacts. *Harmful Algae*, 12:119-124, 2011.
22. Wolfram Research. Mathematica 12.0, 2019.
23. Patricia B. Roth, Michael J. Twiner, Christina M. Mikulski, Amanda B. Barnhorst, and Gregory J. Doucette. Comparative analysis of two algicidal bacteria active against the red tide dinoagellate karenia brevis. *Harmful Algae*, 7(5):682-691, 2008.
24. Patricia B. Roth, Michael J. Twiner, Zhihong Wang, Marie-Yasmine Bottein Dechraoui, and Gregory J. Doucette. Fate and distribution of brevetoxin (pbtx) following lysis of karenia brevis by algicidal bacteria, including analysis of open a-ring derivatives. *Toxicon*, 50(8):1175-1191, 2007.
25. D. F. Ryder and D. DiBiasio. An operational strategy for unstable recombinant dna cultures. *Biotechnology and Bioengineering,* 26(8):942-947, 1984.
26. Hal L. Smith and Paul Waltman. *The Theory of the Chemostat: Dynamics of Microbial Competition.* Cambridge Studies in Mathematical Biology (Book 13). Cambridge University Press, reissue edition, 2008.
27. H.L. Smith. *Monotone Dynamical Systems: An Introduction to the Theory of Competitive and Cooperative Systems.* Mathematical surveys and monographs. American Mathematical Society, 2008.

28. Gregory Stephanopoulos and Gary R. Lapudis. Chemostat dynamics of plasmid-bearing, plasmid-free mixed recombinant cultures. *Chemical Engineering Science*, 43(1):49-57, 1988.
29. William G. Sunda, Cheska Burleson, D. Ransom Hardison, Jeanine S. Morey, Zhihong Wang, JenniferWolny, Alina A. Corcoran, Leanne J. Flewelling, and Frances M. Van Dolah. Osmotic stress does not trigger brevetoxin production in the dinoagellate karenia brevis. *Proceedings of the National Academy of Sciences,* 110(25):10223-10228, 2013.
30. Horst R. Thieme. Convergence results and a poincare-bendixson trichotomy for asymptotically autonomous differential equations. *Journal of Mathematical Biology*, 30:755-763, 1992.
31. Horst R. Thieme. Persistence under relaxed point-dissipativity (with application to an endemic model). *SIAM J. Math. Anal.*, 24:407{435, 1992.
32. Paul Waltman and James Braselton. A mathematical model of a biological arms race with a dangerous prey. *Journal of Theoretical Biology,* 218(1):55-70, 2002.

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Knowledge, Attitude, Epidemiological Risk Factors and Prevention Practices of Japanese Encephalitis in Community Members of Kathmandu and Morang Districts, Nepal

By A. Chapagain, P. Ghimire & M. P. Gupta
Tribhuvan University,Nepal

Abstract- A research was conducted among communities' members of Kathmandu and Morang districts to study knowledge, attitude, epidemiological risk factors, and prevention practices of Japanese Encephalitis (JE) based on a questionnaire survey. In this study, 100 pig farmers were surveyed from each district to assess the knowledge, attitude, epidemiological risk factors and prevention practices for Japanese encephalitis virus (JEV) infection. In Kathmandu, 42% pig farmers were aware of JE while in Morang only 25% were having knowing of it; the finding was significantly different ($P<0.05$) concerning district, literacy, and gender of pig farmers. 87% pig farmers of Kathmandu and 13% of Morang were using the vaccine for other diseases in pigs there was no practice of vaccination against JE. Pig farmers were using mosquito bite prevention practices. Despite some differences, pig farmers were found to be exposed to multiple JE risk factors, having a low level of awareness, and not using adequate prevention practices.

Keywords: *japanese encephalitis, japanese encephalitis virus, insecticide treated nets, vaccination, communities member, questionnaire, mosquito bite.*

GJSFR-D Classification: *FOR Code: 070799*

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Abstract- A research was conducted among communities' members of Kathmandu and Morang districts to study knowledge, attitude, epidemiological risk factors, and prevention practices of Japanese Encephalitis (JE) based on a questionnaire survey. In this study, 100 pig farmers were surveyed from each district to assess the knowledge, attitude, epidemiological risk factors and prevention practices for Japanese encephalitis virus (JEV) infection. In Kathmandu, 42% pig farmers were aware of JE while in Morang only 25% were having knowing of it; the finding was significantly different ($P<0.05$) concerning district, literacy, and gender of pig farmers. 87% pig farmers of Kathmandu and 13% of Morang were using the vaccine for other diseases in pigs there was no practice of vaccination against JE. Pig farmers were using mosquito bite prevention practices. Despite some differences, pig farmers were found to be exposed to multiple JE risk factors, having a low level of awareness, and not using adequate prevention practices. There was no uptake of JE vaccine among pig farmers of both districts. For prevention and control of JE, there is need of public awareness, vaccination to human and pig against JE, provision of using insecticide treated-mosquito nets, management of pig farms and scientific rice field irrigation management to curve over JE.

Keywords: japanese encephalitis, japanese encephalitis virus, insecticide treated nets, vaccination, communities member, questionnaire, mosquito bite.

I. Introduction

Japanese encephalitis (JE) is a mosquito-borne zoonotic disease. The disease was been caused by an arbovirus of the Flaviviridae family (Lindenbach and Rice, 2001). First clinical identification was made in 1871 in Japan, and previously, this disease was known as "summer encephalitis" (Mackenzie *et al.*, 2007). In 1933, the virus responsible for Japanese Encephalitis B (JEB) was re-isolated and ultimately characterized in 1934 when it had been experimentally inoculated into the monkey brain and successfully reproduced the disease (Jani, 2009). It is the single largest cause of viral encephalitis in the world (Kinchi *et al.,* 2010), with annual case reports ranging from 30,000-50,000 (Solomon, 2006) but, estimations are even higher (Tsai, 2000).

For JEV transmission, ardeid wading birds are the primary maintenance hosts, pigs are the main amplifying hosts, and *Culex* mosquitoes are the primary mosquito vectors for transmission (Igarashi, 2002). In Nepal, ducks also have been incriminated as the potential risk factor for JEV transmission (Joshi *et al.,* 2004 and Pant, 2006). The disease now has been firmly established in Morang and Kathmandu districts both with several cases being admitted to different area hospitals each year. Pig farming as lucrative business has been increasing not only in these two districts but all over the country due to, requiring a comparatively small investment, quick return providing nature and being a highly prioritized sector by the government as means of poverty alleviation through a cooperative approach. Most of these farms however, are maintained under unsanitary and unhygienic practices. Since pig develops prolonged viraemia after JEV infection, pig rearing in presence of other risk factors such as wild birds, ducks, mosquito vectors, rice field and standing water sources may be a high risk occupation in JE endemic area of Nepal (Chapagain *et al.,* 2018).

This study tries to find out the socio-demographic features of pig farming community, exposure to epidemiological risk factors for JE, knowledge level, and prevention practices against JE, and future extension education opportunities in these communities. Further, the main purpose of this study was to find out whether there exists regional variation in knowledge, epidemiological risk factors, and prevention practices regarding the Japanese encephalitis among the community members of pig farmers of Kathmandu and Morang districts.

II. Materials and Methods

This study was carried out in two JE endemic districts, Kathmandu and Morang districts of Nepal. The areas on the study districts were selected in

Author α: Corresponding author: Faculty, Institute of Agriculture and Animal Science,Tribhuvan University, Paklihawa Campus, Rupandehi, Nepal. e-mail: chapagain.arjun@gmail.com
Author σ: Nursing Instructors, Bharatpur Hospital Nursing Campus, Chitwan, Nepal. e-mail: puspaghmr88@gmail.com
Author ρ: Faculty, Faculty of Animal Science, Veterinary Science and Fisheries, Agriculture and Forestry University, Rampur, Chitwan. e-mail: mohangupta63@yahoo.com

correspondence with the local district government officials, and field level veterinarians of the respective districts.

a) Sampling procedure

i. *Sampling of pig farmers in study districts for questionnaire*

Farm count in each district

Total pig farms of both districts were counted by visiting those areas under the guidance of community leaders and local para-veterinarians, and sites were selected for each district. Sample size was then calculated by random proportional sampling method comprised of 100 pig farm families in each district.

The pig farmers in Kathmandu valley consists of Balaju, Jatibuti-Manahara, Gokarna, and Gothatar, and was 19, 33, 20, and 28 respectively. Similarly, in Morang district the sites consist of Urlabari, Biratnagar, and Madhumalla, and were 28, 37, and 35 respectively.

ii. *Farm selection for questionnaire survey*

The Simple random sampling procedures were performed for the selection of farms from each study site. For this, the complete list of pig farmers of each was prepared, and the lottery was done separately to select the desired number of pig farms for each. The Questionnaire was, and administered to assess the knowledge, attitude, exposure to the epidemiological risk factor, and prevention practices followed by community member of pig farmers. The questionnaire was pre-tested in a region outside of the study area, and the semi-structured questionnaire was finally prepared, and used for survey in the study districts.

b) Statistical analysis

Data collected were analyzed by Chi-square test using descriptive statistics of SPSS version 16. The p-value less than 0.05 were taken as significant for the association or non-association of the variables.

III. Result and Discussion

a) Comparison of socio-demographic features

i. *Gender Respondents*

In this study, two districts, Kathmandu, and Morang were selected. In Kathmandu, the male and female respondents' were equal in number. In Morang, district, male was higher 58% in number than females 42%. However, statistically, there were no significant differences in sex of respondents in two districts ($p>0.05$).

Table 1: Distribution of respondents' from study areas in Kathmandu district

Study site	Gender of farmer		Total
	Male	Female	
Balaju	12	7	19
Gokarna	10	10	20
Jadibuti-Manahara	15	18	33
Gothatar	13	15	28
Total	50	50	100

Table 2: Distribution of respondents' from study areas in Morang district

Study site	Gender of farmer		Total
	Male	Female	
Urlabari	10	18	28
Biratnagar	27	10	37
Madhumalla	21	14	35
Total	58	42	100

ii. *Education level*

There was a significant difference in two regarding the illiteracy status of pig farmers ($p<0.05$). In Kathmandu, 39% of farmers were illiterate while in Morang more than half (55%) were illiterate. Six of % pig farmers in Kathmandu had college-level education while only 1% had that much in Morang district. Kathmandu is the capital of the country, which might be the reason for the higher literacy of pig farmers compared to the Morang district.

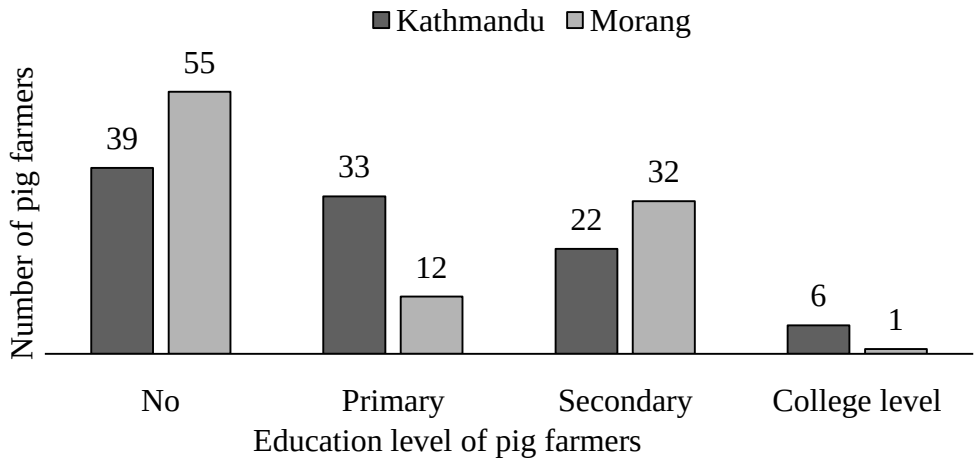


Figure 1: The Education level of pig farmers in Kathmandu and Morang districts

b) Farmers receiving training

In Kathmandu, 16% of pig farmers had the training as compared to Morang, which had value of 1%. In Kathmandu governmental offices stood first in providing training (11/16) followed by farmer group (3/16) and NGO/INGO (2/16). In Morang only one pig farmer had the training, and NGO/INGO being the one who provide training.

There was no significant difference in reasons behind the not taking training in both districts. The major of them responded with didn't know where to go for training followed by didn't know where training was available, and can't afford training.

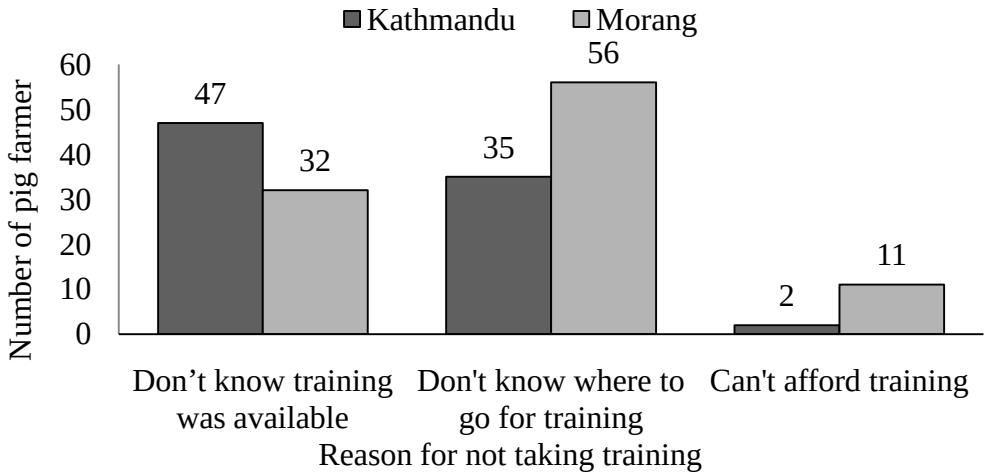


Figure 2: Reason for not taking training

Table 3: Socio-demographic features in Kathmandu and Morang districts

Parameters	Class	Kathmandu	Morang	P value
Gender	Male	50	58	0.160
	Female	50	42	
Education	Illiterate	39	55	0.017
	Literate	61	45	
Income (monthly)	≤ 10000 NRS	70	95	<0.001
	> 10000 NRS	30	5	
Sole occupation as pig farming		73	18	<0.001
Own land for pig farming		15	65	<0.001
Time lapse since raising pigs	≤ 3 years	27	16	0.042
	> 3 years	73	84	

c) *Knowledge of Japanese encephalitis among pig farmers*

In Kathmandu district, the number of pig farmers who had heard about JE was higher than Morang, and were 42% (42/100), and 25% (25/100) respectively. There was variation in their knowledge about other facts related to JE. Thirty-three farmers in Kathmandu and 13 in Morang knew what problem it causes in human, 7 in Kathmandu and 8 in Morang knew what problem it causes in pigs. Twenty people in Kathmandu and 13 in Morang knew how it transmits. Eleven in Kathmandu and 3 in Morang knew it is vaccine preventable in pig while 19 people in Kathmandu and 9 in Morang knew it is vaccine preventable in human beings.

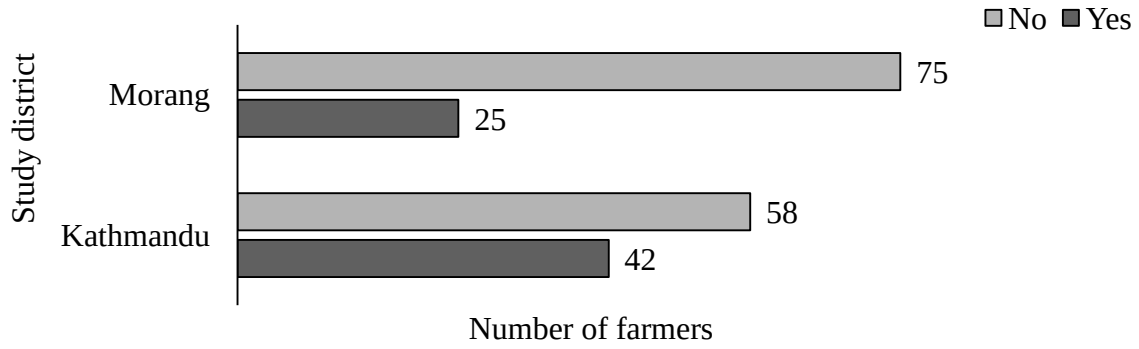


Figure 3: Farmers who had heard about JE

In Kathmandu district, pig farming community people were found to be the source of information for JE. Out of 42 pig farmers who had heard about JE in Kathmandu, 20 said pig farmers and pig farming community as the source of information, 16 said media while 6 said other sources. In Morang, stood first were media, 19 people out of 25 said it as the source of JE knowledge followed by friends and community by two people and other sectors by 4. Other sources included academic study, trainings, and health sector (Figure 4).

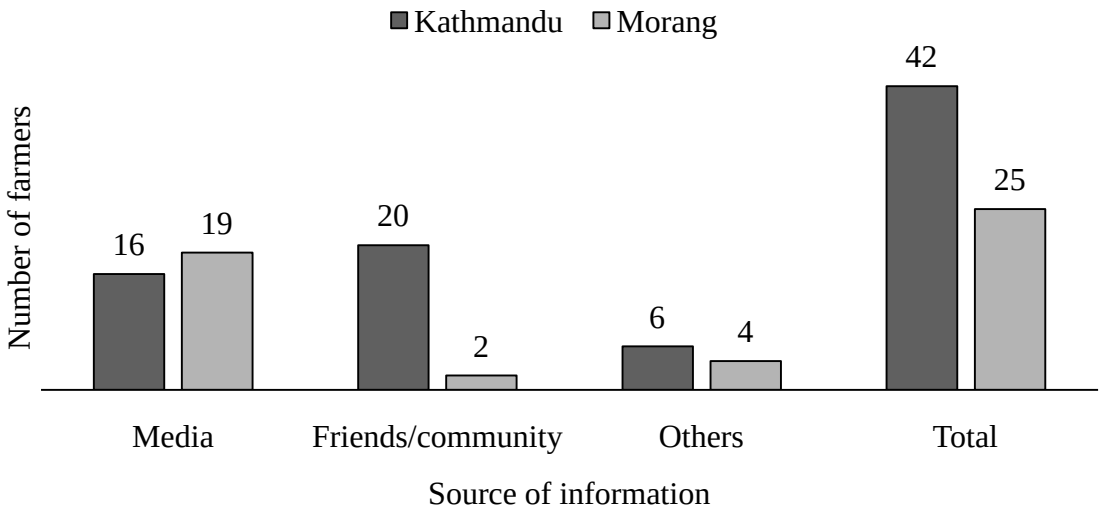


Figure 4: Source of information about JE

d) *Knowledge about JE facts in study districts*

Seventy two percent (72%) of pig farmers in Kathmandu knew they could get the disease from pigs. While in Morang, 39% of pig farmers knew this fact, and there was a significant difference by awareness regarding the pig borne zoonoses in two districts regarding ($p<0.001$). Kathmandu had more pig farmers that were aware of pig borne zoonoses than of Morang district. In Kathmandu, 42% of pig farmers had heard about JE while in Morang only 25% had heard about it. A Similar study in Rupandehi and Kapilvastu district by Khanal (2012) also showed a similar low level of knowledge, 38% of pig farmers of Rupandehi, and 15% of pig farmers of Kapilvastu knew about JE. The surveyed were also conducted among 100 pig farmers from Rupandehi, and 100 from Kapilvastu district.

Table 4: Pig farmer's knowledge regarding JE facts

JE facts		Kathmandu (N=100)	Morang (N=100)
Knowledge on problems in human	Yes	33	13
	No	67	87
Knowledge in problem in pig	Yes	7	8
	No	93	92
Knowledge on how it spreads	Yes	20	13
	No	80	87
Knowledge on vaccine for prevention in pig	Yes	11	3
	No	89	97
Knowledge on vaccine for prevention in human	Yes	19	9
	No	81	91

e) *Relationship between knowledge, and other socio-demographic features among farmers of study districts*

In Morang, only 25% of farmers had heard about JE. There was a significant difference in Gender associated with JE knowledge ($p<0.05$). More males were aware about JE knowledge than females in the study districts, and were the factor responsible in the variation of JE knowledge. In Kathmandu, 47 out of 108 (42%) of pig farmers males had heard about JE while only 20 out of 92 (21.7%) of females had heard about it ($P<0.05$).

Literacy status and heard about JE had a significant association ($p<0.05$) among the pig farmers. Forty four 44 out of 106 (41.5%) of literate farmers had heard about JE while only 23 out of 94 (24.5%) illiterate pig farmers had heard about JE.

Table 5: Association of various variables with knowledge

Variables tested	Chi-squared value	p value
Study district and heard about JE or not	6.486	0.008
Gender and heard about JE or not	10.578	0.001
Time period of raising pig and heard about JE or not	2.808	0.069
Literacy and heard about JE or not	6.494	0.008
Training on pig farming and heard about JE or not	3.153	0.069
Know people can get disease from pigs and heard about JE or not	25.695	<0.001

f) *Exposure to epidemiological risk factors*

i. *Wild bird exposure in a farm, duck farming and exposure to the mosquito bite*

In both districts, pig farmers had encountered wild birds in their farm periphery. These birds were there to take feeds allocated for pigs. The various kinds of birds had been reported including crane, cattle egrets, Mynah, crow, etc.

Table 6: Various types of birds encountered around pig farm by pig farmers in Kathmandu

Type of birds	Kathmandu (percentage)	Morang (percentage)
Crow	50	21
Mynah	4	13
Crane	3	2
Many kind of birds	40	35
Don't Know	3	29
Total	100	100

In Kathmandu, 39% of pig farmers had duck farming while the rest 61% had ducks within 1 Km distance from the farm. In Morang district, 14% of pig farmers had duck farming, and 78% of all (78/100) had ducks within 1 Km distance. In Kathmandu and Morang all pig farmers had encountered mosquitoes in a pig farm and in and around their house. 68% of them reported they had observed mosquitoes biting pigs in Kathmandu while 37% reported mosquito bites in pigs.

g) *Closeness to pig shed, rice field, and water sources*

Regarding closeness to pig from human dwelling all houses were within 20 meter distance from pig pens in Kathmandu district and within 500 meter in Morang. For 95% of households in Kathmandu, the rice fields were within 1 Kilometer distance, and for 99% the standing water bodies were within 1 Kilometer. In Morang, 88% of households were within 1 Kilometer from rice fields, and 91% within 1 Kilometer distance

from water sources that can form potential mosquito breeding sites.

Table 7: Comparison of closeness to the pig farm, rice fields and standing water bodies from human dwelling in Kathmandu and Morang districts

Parameters		Kathmandu	Morang	P value
Closeness to pig farm	≤ 500 mtr	100	100	-
	> 500 mtr	-	-	
Closeness to rice field	≤ 1 Km	95	88	
	> 1 Km	5	12	0.063
Closeness to large standing water bodies	≤ 1 Km	99	91	0.009
	> 1 Km	1	9	

h) Preventive measures against mosquito bites

When considered for the use of mosquito bite prevention techniques in human, use of window screen, use of repellents, use of mosquito nets, improving drainage, use of mosquito coils, staying indoor (inside) at dawn, and dusk and wearing clothes that cover full body had been evaluated. In Kathmandu maximum, 69% of pig farmers were using mosquito coils followed by practice of using net by 41. In Kathmandu, 11% of farmers were using window screen, 25% using repellants, 39% using the of staying indoors at dawn or dusk, 40% used to wear clothes that cover full body, and 38% were practicing improved drainage. In Morang, improved drainage was being practiced by many (71%) followed by the practice of a mosquito net (51%). In Morang district, 8% were using window screen, 8% using repellants, 49% using a mosquito coil, 22% practiced staying indoors at dawn or dusk to avoid mosquito bites, and 22% wore clothes that covers the full body.

Table 8 : Mosquito bite prevention methods used in Kathmandu and Morang districts

Mosquito bite prevention methods for human	Kathmandu	Morang
Use window screen	11	8
Use repellants	25	8
Use mosquito coil	69	49
Stay indoors at dawn/dusk	39	22
Wear clothes that covers full body	40	22
Improve drainage	38	71
Use mosquito net	41	51

In Kathmandu, 17 pig farmers were using mosquito avoiding practices in pig farms as well. These include spraying chemicals (10/17), maintaining cleanliness (1/17), lightning fire, and smoking (5/17) and using repellents (1/17). In Morang, 19 pig farmers were practicing mosquito avoiding techniques in a farm as well, which included spraying chemicals (12/19), lighting fire and smoking (5/19) and maintaining cleanliness (2/19).

Table 9: Mosquito avoiding practices used by pig farmers in Kathmandu and Morang

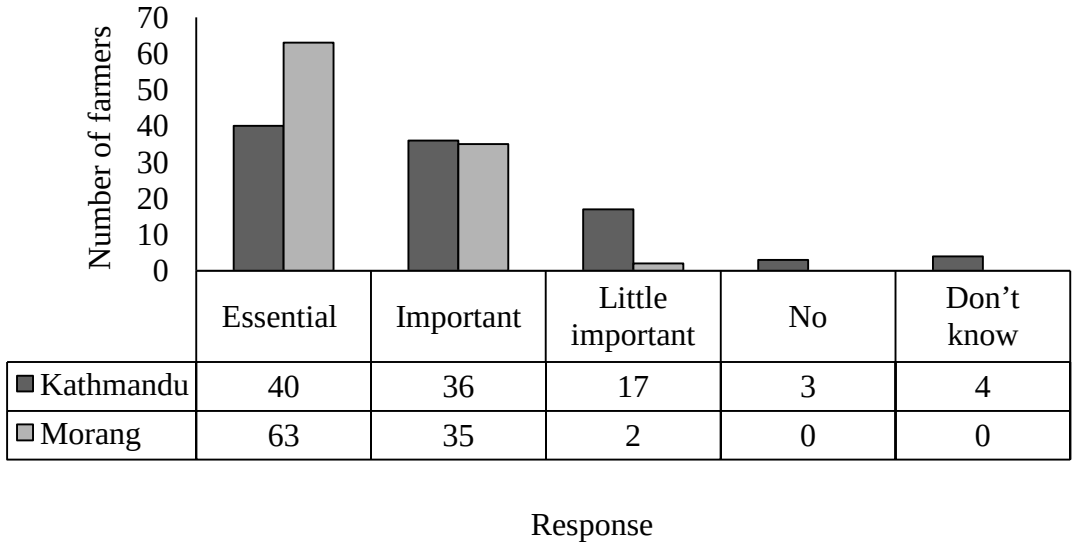
Mosquito bite prevention methods for pigs	Kathmandu (n=17)	Morang (n=19)
Spraying chemicals	10	12
Maintaining cleanliness of farm	1	2
Lightning fire and smoking	5	5
Using repellants	1	-

i) Vaccination to human and pig

i. *Human vaccination*

In Kathmandu district, 77 farmers had heard about the vaccine. Among them, 46 remembered they had vaccinated against at least any vaccine. In Morang district, 97 farmers had heard about the vaccine. However, only 20 could remember at least any vaccine being used by themselves. None of them had vaccinated themselves against JE.

When asked how important vaccines are to keep themselves healthy three said no, 17 said little important, 36 said important, 40 said essential, and four said they didn't know in Kathmandu. However, in Morang, 63 farmers said it's, 35 said important, and two said little.



	Essential	Important	Little important	No	Don't know
Kathmandu	40	36	17	3	4
Morang	63	35	2	0	0

Figure 5: Importance of vaccine for themselves as perceived by farmers

Among Kathmandu farmers, when asked where they prefer to go for vaccination 55 of them said government health center, 21 said private health clinic and 24 said vaccination campaign run by the government. In Morang, 84 of them said government health center, 14 said the vaccination campaigns by government and 2 said the private health center.

ii. *Pig vaccination*

Out of 100 pig farmers in Kathmandu, five said vaccines are not for pigs, 12 a little, 44 said important, 35 said essential, and four didn't know. In Morang district, two said not, 43 said a little important, 40 said important, 13 essential and 2 said they don't know (Figure 6).

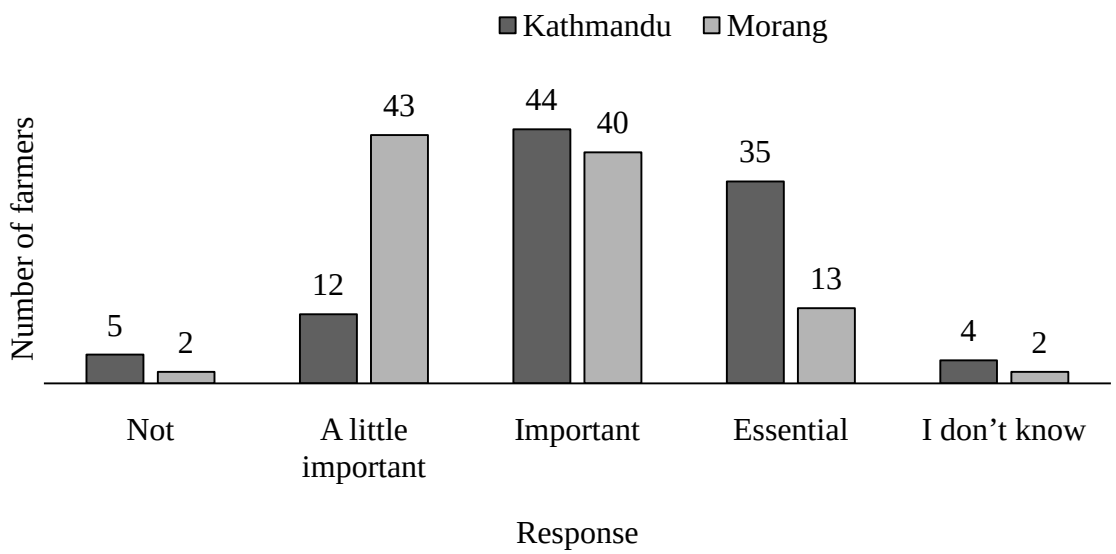


Figure 6: Importance of vaccination to pig as perceived by pig farmers

In Kathmandu, 87% of pig farmers were vaccinating pigs against at least one disease while in Morang, only 13% vaccinating against at least one. Para-veterinarians vaccinated pigs mostly in both districts while in some farm, the farmers vaccinated themselves as well (Figure 7). When asked about whom they trust in immunization of pigs or who recommended vaccination areas, they said the veterinarians or para-veterinarians being the most trustable source.

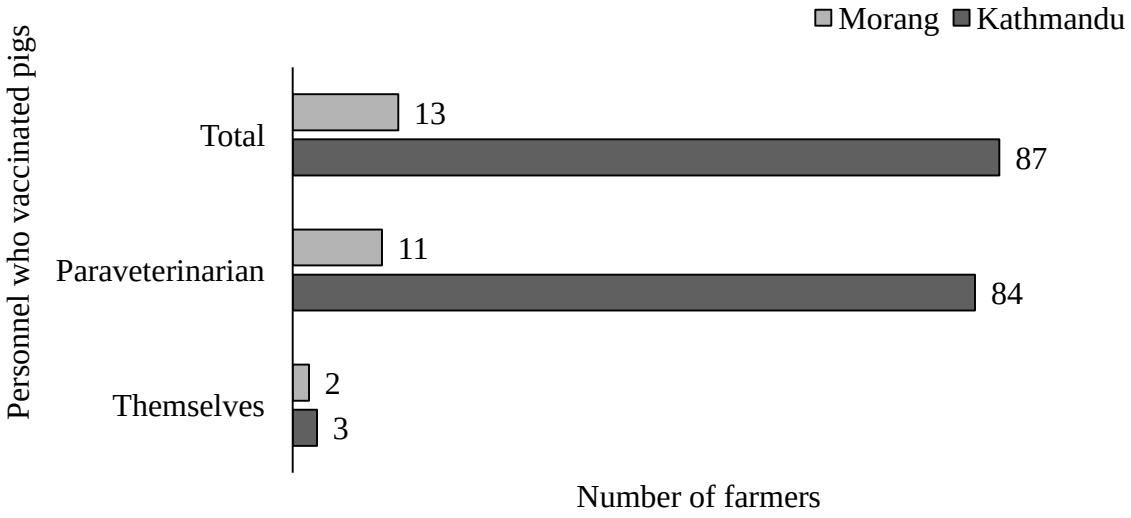


Figure 7: Who vaccinated pigs?

In Kathmandu, thirteen percent (13/100) pig farmers had not vaccinated pigs. When asked for the reason, seven said they didn't know pigs need vaccine, and six said they had no problem in pigs. In Morang, 87% (87/100) pig farmers had not the pigs. 39/87 didn't know pigs need, 42/87 had no problems in pig so not, 4/87 said they couldn't afford vaccine, and remaining two said they didn't think vaccine works (Figure 8).

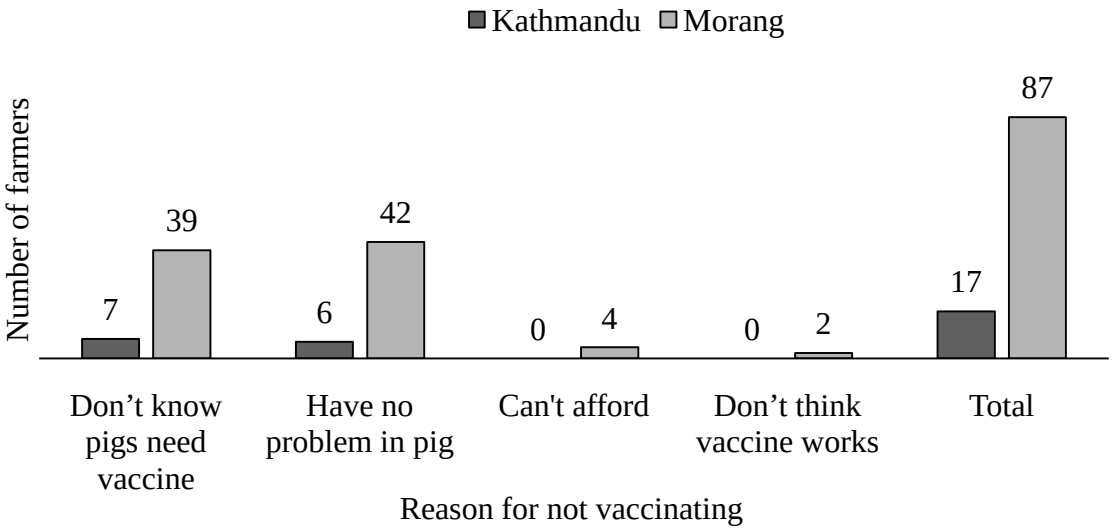


Figure 8: Reason for not vaccinating pigs

IV. Conclusions

Pig farmers in both study districts were exposed to multiple JE risk factors. The pig pens are very close to human dwellings. Human houses have a close distance to mosquito breeding sites like rice fields. Pig farming community people were frequently exposed to wild birds, ducks, and mosquito bites. Though some differences exist between Kathmandu and Morang study areas, the risk of JE is higher in both districts. Prevention practices are mainly mosquito bite prevention and immunization. We found a low level of mosquito bite avoiding practices was being used by the pig farmers in both. Use of bed nets, use of mosquito coils, etc. were very limiting and not adequate. There is a need to make the community people aware of the need and importance of using mosquito avoiding practices like using bed nets. Insecticide-treated-nets should be made available to all to prevent vector-borne diseases like JE. Immunization against JE was also not found in pig farmers as well as in pigs they raise. The vaccination campaigns run by governments should be in reach of all, including the poor pig farmers. Government as well as non-government sectors should think over the need of immunization of pigs against JE and should make necessary arrangements for this.

The awareness level for Japanese Encephalitis was not adequate in both districts. Regional variations were found towards knowledge of JE. Awareness level were more in Pig farmers of Kathmandu than pig farmers of Morang The effect of being located in the capital have been seen here. Awareness varied with the sex of respondent as well, where more males were aware compared to females. Further, the literacy rate also determined for JE. The relationship of literacy status with JE awareness showed that could have been improved with improving literacy status of the farmer. This could suggests that there is a need for strengthening literacy status, whether through formal or informal education. Training and awareness generation campaigns can also have a potential impact on making pig farmers aware of diseases like JE and need of such programs in JE endemic areas is felt after the findings of this study. Media and friends involved in pig farming were being the source of information for JE. Medias like radio, television thus could be the potential sources for generating awareness to the pig farmers. However, the illiteracy rate as well as gender differences in knowledge should be taken under consideration before using printed materials as the means of extension education or before conducting educational campaigns. Many cases of JE might have been gone unnoticed. So there is need for strengthening the laboratory facilities as well in regional and peripheral levels.

The pig farming communities in both districts were illiterate, landless, and poor. They neither have commercialized pig farming, nor do they have a good secondary occupation. They were unlikely to invest much, and adopt the necessary adjustments on the farm like the use of bio-security measures. Further, the income they are getting from pig farming also doesn't allow them to invest much on-farm improvements, on human and pig immunization or other issues of JE prevention and control. Thus, this study shows there is a need for providing proper training on pig farming, providing financial assistance regarding support and commercialization of farms, providing the land for farming and improving income of the farmers by ensuring markets for the finished products. Then only best way to prevent and control JE in the context of Nepal is to vaccinate the pigs and Humans.

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The pig farmers and community members of Kathmandu, and Morang districts who supported this research project were highly acknowledged. The authors are also highly thankful to Director of Research (DoR) / Institute of Agriculture and Animal Science (IAAS), NARDF (National Agricultural Research and Development Fund), the research crew of National Zoonosis, and Food Hygiene Research Centre (NZFHRC), and all who supported directly and indirectly help during the research duration and preparing this final draft.

References Références Referencias

1. Bhatta, L. R., Wierzba, T., Joshi, A. B., & Banjara, M. R. (2008). Status and Trend of Japanese Encephalitis Epidemics in Nepal: A Five-Year Restrospective Review. *Journal of Nepal Health Research Council*.
2. Chapagain, A., Singh, S., & Thapa, D. B. (2018). Knowledge Regarding Japanese Encephalitis among Pig Farmers of Kathmandu and Morang Districts of Nepal. *Journal of the Institute of Agriculture and Animal Science*, *35*(1), 225-234.
3. Chapagain, A., Singh, S., Thapa, D. B., & Bhattarai, D. (2018). Swine Sero-Status of Japanese Encephalitis among Kathmandu and Morang Districts of Nepal. *International Journal of Applied Sciences and Biotechnology*, *6*(4), 373-378.
4. Dhakal, S., Joshi, D. D., Ale, A., Sharma, M., Dahal, M., Shah, Y., & Stephen, C. (2014). Regional variation in pig farmer awareness and actions regarding Japanese encephalitis in Nepal: implications for public health education. *PloS one*, *9*(1), e85399.
5. Dhakal, S., Stephen, C., Ale, A., & Joshi, D. D. (2012). Knowledge and practices of pig farmers regarding Japanese encephalitis in Kathmandu, Nepal. *Zoonoses and public health*, *59*(8), 568-574.
6. Igarashi, A. (2002). Control of Japanese encephalitis in Japan: immunization of humans and animals, and vector control. In *Japanese Encephalitis and West Nile Viruses* (pp. 139-152). Springer, Berlin, Heidelberg.
7. Jani, P. (2009). Evolution and distribution of Japanese Encephalitis virus in Asia. *Am. J. Trop. Med. Hyg*, *81*(6), 118-9.
8. Jani, P. (2009). Evolution and distribution of Japanese Encephalitis virus in Asia. *Am. J. Trop. Med. Hyg*, *81*(6), 118-9.
9. Khanal, T. (2012). *Knowledge, attitude and risk factors of Japanese encephalitis in community members of Rupandehi and Kapilvastu districts, Nepal* (M. Sc. thesis (unpublished), Institute of Agriculture and Animal Science, Tribhuvan University, Rampur, Chitwan, Nepal).
10. Khanal, T., Dhakal, I. P., Pandey, K., & Dutt, D. D. (2014). Knowledge and epidemiological risk factors of Japanese encephalitis in community members of Rupandehi District, Nepal. *Global Journal of Medical Research*.
11. Khinchi, Y. R., Kumar, A., & Yadav, S. (2010). Study of acute encephalitis syndrome in children. *Journal of College of Medical Sciences-Nepal*, *6*(1), 7-13.
12. Lindenbach, B. D., & Rice, C. M., (2001). Flaviviridae: The viruses and their replication, *In*:

D.M.H.P. Knipe (Ed.). Fields virology. 4th edition, 991-1042. Philadelphia: Lippincott Williams and Wilkins.

13. Mackenzie, J. S., Williams, D. T., & Smith, D. W. (2006). Japanese encephalitis virus: the geographic distribution, incidence, and spread of a virus with a propensity to emerge in new areas. *Perspectives in medical virology*, *16*, 201-268.
14. Mackenzie, J. S., Williams, D. T., & Smith, D. W. (2006). Japanese encephalitis virus: the geographic distribution, incidence, and spread of a virus with a propensity to emerge in new areas. *Perspectives in medical virology*, *16*, 201-268.
15. MoAC. (2010). Livestock population and their distribution. Ministry of Agriculture and Co-operatives, Nepal.
16. Pant, G. R., (2006), A serological survey of pigs, horses, and ducks in Nepal for evidence of infection with Japanese encephalitis virus. *Annals of the New York Academy of Sciences*, *1081*(1), 124-129.
17. Pant, G. R., Lunt, G. R.., Rootes, C. L., & Daniels, P. W. (2006). Serological evidence for Japanese encephalitis and West Nile viruses in domestic animals of Nepal. *Comparative immunology, microbiology and infectious diseases*, *29*(2-3), pp.166-175..
18. Solomon, T. (2006). Control of Japanese encephalitis—within our grasp?. *New England Journal of Medicine*, *355*(9), 869-871.
19. Tsai, T. F. (2000). New initiatives for the control of Japanese encephalitis by vaccination: Minutes of a WHO/CVI meeting, Bangkok, Thailand, 13–15 October 1998. *Vaccine*, *18*, 1-25.

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Standard Procedure and Time Setting for Servicing of Single Jersey and Double Jersey Knitting Machine

By Md. Ebrahim Shaikh, Md. Sanaullah Murad,Taposh Ranjan Sarker & Tahmina Akhter
Northern University Bangladesh

Abstract- A study on standard procedure and time setting for servicing of single jersey and double jersey knitting machine is done in this work. Servicing, maintenance, use of lubrications procedure also studied in this project wok. Servicing is a very vital point for keep machine performance well and for better fabric quality. Here we worked on single jersey and double jersey knitting machines servicing procedure, and time setting.

Keywords: *time setting, servicing of knitting machine, standard procedure.*

GJSFR-D Classification: *FOR Code: 079999*

Strictly as per the compliance and regulations of:

Standard Procedure and Time Setting for Servicing of Single Jersey and Double Jersey Knitting Machine

Md. Ebrahim Shaikh [α], Md. Sanaullah Murad [σ], Taposh Ranjan Sarker [ρ] & Tahmina Akhter [ω]

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I. Introduction

In the world of textile technologies, there has been a lot of attempt going on to find out effective quality, productivity, efficiency and longevity. Circular knitting machine is the first choice for knitted Fabric manufacturers. It is widely used throughout the knitting industry to produce fabric for its productivity and user friendliness. It has been designed and manufactured for mass production of knitted fabric. Huge range of diameter (12 inch to 60 inch) according to manufactures requirement that is perfect for manufacturing outerwear and innerwear. In this article I will explain how yarn pass through circular knitting machine. It has also been discussed about different parts of circular knitting machine with their functions.

a) Objectives

The objective of this study is to achieve the following:

1. To know standard procedure of servicing of single jersey and double jersey knitting machine(circular).
2. To know proper time setting of servicing of single jersey and double jersey knitting machine(circular).
3. To reduce lost time of servicing of knitting machine.
4. To increase knitting machine efficiency.
5. To increase knitting machine longevity.
6. To improve fabric quality.

Md. Ebrahim Shaikh α: Lecturer, Department of Textile Engineering, Northern University Bangladesh.
e-mail: butexianebrahimfme06@ gmail.com
Md. Sanaullah Murad σ: Lecturer, Department of Textile Engineering, Northern University Bangladesh. e-mail: textilemurad@gmail.com
Taposh Ranjan Sarker ρ: Lecturer, Department of Textile Engineering, Northern University Bangladesh.
e-mail: taposhsarker.butex@gmail.com &
Tahmina Akhter Nipu ω: Lecturer, Department of Textile Engineering, Northern University Bangladesh. e-mail: niputahmina045@gmail.com

II. Literature Review

a) Circular Knitting Machine

Knitted fabrics are produced by interlacing loops of yarn and can be classified as weft knits and warp knits. The knitting considered in this section is machine knitting. [5]

Circular knitting machine is widely used throughout the knitting industry to produce fabric. This machine can be built in almost any reasonable diameter and the small diameter of up to five, which are used for wear. Machine for outerwear and innerwear may vary from 12 inch to 60 inch in diameter according to manufactures requirement. This machine can be used either as fabric or for making garments completely with fancy stitch. Latch needle are commonly employed in all modern circular machines because of their simple action and also their ability to process more types of yarns.

b) Important Parts of Circular Knitting Machine

Creel: The creel of the knitting machine controls the placement of yarn packages (bobbins) on all machines. Modern large-diameter circular machines use separate side creels, which are able to hold a large number of packages in a vertical position. [1]

VDQ Pulley: It controls the quality of the product. Altering the position of the tension pulley changes the G.S.M. of the fabric. If pulley moves towards the positive directive then the G.S.M. is decrease and in the reverse direction G.S.M will increase.

Pulley Belt: It controls the rotation of the MPF wheel.

Brush: It cleans the pulley belt.

Inlet and Outlet Stop Motion: It stops the machine instantly when a yarn is break.

Yarn Guide: It helps the yarn to feed in the feeder.

MPF Wheel: It controls the speed of the MPF. Pulley belt gives motion to the wheel.

MPF: It is Memminger positive feed. It gives positive feed to the machine.

Feeder Ring: It is a ring where all feeders are placed together.

Feeder: Feeder helps yarn to feed in to the machine.

Needle Track: Where all needles are placed together in a decent design.

Needle: It is a principal element of the knitting machine. Its help the yarn to create a loop.And by this way fabric are produce. Prior to yarn feeding the needle is raised to clear the old loop from the hook, and received the new loop above it on needle stem. The new loop is then enclosed in the needle hook as the needle starts to descend.

Sinker: It is the most important element of the machine. Its help to loop forming, knocking over and holding down the loop.

Sinker Ring: Sinker ring is a ring. Where all sinkers are placed together.

Fabric-batching roller: The fabric, in tubular form, is drawn downwards from inside the needle cylinder by tension rollers and is wound onto the fabric-batching roller of the winding-down frame. [4]

Cam Box: Where the cams are set horizontally.

Cam : The knitting cams are hardened steels and they are the assembly of different cam plates so that a track for butt can be arranged. Each needle movement is obtained by means of cams acting on the needle butts. [2]

Lycra Attachment Device: Lycra is placed here and fed to the machine.

Lycra Stop Motion: It is one kind of stop motion to stop the machine when the Lycra is break.

Cylinder : Needle track are situated here.

Cylinder Balancer: It helps the cylinder to set in a proper alignment.

Uniwave Lubrication: The Uniwave lubricator provides uniform lubrication to needles, cam tracks, lifters and other knitting machine components. The patented nozzle construction separates the air-oil mixture into air and droplets of oil.

Adjustable Fan: This part removes lint, hairy fibre from yarn and others. To clean the dust by air flow.

Expander: To control the width of the knitted fabric. No distortion of the knitting courses. Even take down tension in the knitting machine. As a result, an even fabric structure is achieved over the entire fabric width. The deformation of the knitted fabric goods can be reduced. [7]

Needle Detector: This part detects the any type of faults of needles.

Air Gun Nozzle: To feed the yarn; sometimes it is used for cleaning purpose.

Take up roller: It is used to take-up the fabric from the knitting machine. Take up roller also controls the proper tension on the fabric. [10]

c) Maintenance

Maintenance is a Procedure by Means of Which We Can Maintain Active Functioning in Operation according To the Behavior and Utility of Particular Elements/Substance. The efficient use of machinery relies on best technology of efficient drive and heating systems combined with good maintenance in production. [6]

i. *Types of Maintenance*

Schedule Maintenance: Here mainly all the machines are checked on the basis of a fixed schedule of time. Different machine parts are opened, cleaned, lubricated, gauged and replaced if necessary.

Preventive maintenance: It is "a routine for periodically inspecting" with the goal of "noticing small problems and fixing them before major ones develop. [8]

Breakdown Maintenance: When a machine stops due to failure of machine parts, then it is called machine breakdown. The maintenance that is done to repair and make it ready to run is called breakdown maintenance.

ii. *Lubricants*

Lubricant is a substance which is placed in between two mating parts which are in relative motion with each other, so that they can move without any friction. At higher temperature they are expected to keep the moving parts apart to minimize wear. [9]

iii. *Function of Lubricants*

1. To reduce the friction and wear between the contact surface.
2. To carry away the heat/to cool the moving elements.
3. To keep the surface clean
4. To prevent adhesion
5. To carry heavy loads
6. To prevent corrosion
7. To absorb shock and transmit hydraulic power.

III. Materials and Methods

a) Materials

Single Jersey Knitting Machine
Brand: Pailung, juinlung, Pillotelly
Double Jersey Knitting Machine
Brand: Pailung, Juinlung

b) Method

Most single-jersey fabric is produced on circular machines whose latch needle cylinder and sinker ring revolve through the stationary knitting cam systems that, together with their yarn feeders, are situated at regular intervals around the circumference of the cylinder. [3]

The method we applied here is based on time and procedure system. We observed how they service machine and after that we applied to calculate the time what they take. And how we can improve it after that we observed to find out minimum time for servicing of knitting machine. Below we described the process as a flow chart.

Table 1: Shows the Flow Chart of Single Jersey Knitting Machine (Servicing)

Sl. No.	Activities	Who	Responsible Person	Standardize Time (min)	Remarks
1	To disconnect the MPF Line	S.M-1	Knitting Master	1	Simultaneo usly
	To disconnect the MPF Belt	S.M-2	Knitting Master		
2	To break all the yarn from feeder	SM-1+S.M-2	Knitting Master	1	Both work from two side
3	To take down fabric through manual drive	S.M-1	Knitting Master	1	Simultaneo usly
	To remove fabric from take down roller	S.M-2	Knitting Master		
4	To run the M/C freely after giving oil on needle & sinker	S.M-1	Knitting Master	20	Simultaneo usly
	To lay down fabric & prepare board to put down needle & sinker	S.M-2	Knitting Master		
5	To disconnect all air pipe from needle & sinker cambox	S.M-1	Knitting Master	1	Simultaneo usly
	To disconnect all oil pipe from needle & sinker cambox	S.M-2	Knitting Master		
6	To open bolt & pin from Needle cambox& Sinker Cambox.	SM-1+S.M-2	Knitting Master	30	Both work from two usly
7	To put down all needle & sinker cambox	SM-1+S.M-2	Knitting Master	5	Both work from two side
8	To open all needle & sinker from trick	SM-1+S.M-2	Knitting Master	20	Both work from two side
9	To clean up the cylinder & take down parts properly	SM-1+S.M-2	Knitting Master	30	Simultaneo usly
10	To clean up all needle & sinker properly	SM-1+S.M-2	Knitting Master	20	Simultaneo usly
11	To clean up all cambox properly	SM-1+S.M-2	Knitting Master	25	Simultaneo usly
12	To clean up all nozzle properly	SM-1+S.M-2	Knitting Master	15	Simultaneo usly
13	To check all needle &sinker	SM-1+S.M-2	Knitting Master	40	Simultaneo usly
14	To check & clean up some others M/C parts(Fan,MPF,Motor, VDQ,Panel board)	SM-1	Knitting Master	10	Simultaneo usly
	To check & clean up some others M/C parts(Grease, Gear Oil push)	S.M-2	Knitting Master		
15	Setting all needle & sinker	SM-1+S.M-2	Knitting Master	30	Both work from two side
16	To keep all cambox on base & set bollt,pin	SM-1	Knitting Master	30	Simultaneo usly
	Setting all cambox	S.M-2	Knitting Master		
17	To tight all bolt properly	SM-1+S.M-2	Knitting Master	20	Both work from two side
18	Setting all nozzle properly	SM-1+S.M-2	Knitting Master	2	Simultaneo usly
19	To feed all yarn through MPF to needle through feeder & give weight on yarn	SM-1+S.M-2	Knitting Master	30	Both work from two side
20	To connect MPF Belt & Line	SM-1+S.M-2	Knitting Master	2	Simultaneo usly

21	To knit fabric through manual drive slowly	SM-1	Knitting Master	5	Simultaneo usly
	To check yarn feeding on needle	S.M-2	Knitting Master		
22	To knit fabric through inch motion up to take down roller	SM-1	Knitting Master	5	Simultaneo usly
	To clean laid fabric & board	S.M-2	Knitting Master		
Total				353	

Now, Table-2 shows the Flow Chart of Double Jersey Knitting Machine (Servicing)

Table 2: Flow Chart of Double Jersey Knitting Machine (Servicing)

Sl. No.	Activities	Who	Responsible Person	Standardize Time (min)	Remarks
1	To disconnect the MPF Line	S.M-1	Knitting Master	1	Simultaneously
	To disconnect the MPF Belt	S.M-2	Knitting Master		
2	To break all the yarn from feeder	SM-1+S.M-2	Knitting Master	1	Both work from two side
3	To take down fabric through manual drive	S.M-1	Knitting Master	1	Simultaneously
	To remove fabric from take down roller	S.M-2	Knitting Master		
4	To run the M/C freely after giving oil on needle	S.M-1	Knitting Master	20	Simultaneously
	To lay down fabric & prepare board to put down needle	S.M-2	Knitting Master		
5	To disconnect all air pipe from Cylinder & Dial cambox	S.M-1	Knitting Master	1	Simultaneously
	To disconnect all oil pipe from Cylinder & Dial cambox	S.M-2	Knitting Master		
6	To open bolt & pin from Cylinder & Dial cambox	SM-1+S.M-2	Knitting Master	20	Both work from two side
7	To put down all Cylinder & Dial cambox	SM-1+S.M-2	Knitting Master	15	Both work from two side
8	To open all needle from Cylinder & Dial trick	SM-1+S.M-2	Knitting Master	50	Both work from two side
9	To clean up the cylinder,Dial& take down parts properly	SM-1+S.M-2	Knitting Master	40	Simultaneously
10	To clean up all needle properly	SM-1+S.M-2	Knitting Master	20	Simultaneously
11	To clean up all cambox properly	SM-1+S.M-2	Knitting Master	40	Simultaneously
12	To clean up all nozzle properly	SM-1+S.M-2	Knitting Master	15	Simultaneously
13	To check all needle	SM-1+S.M-2	Knitting Master	30	Simultaneously
14	To check & clean up some others M/C parts(Fan,MPF,Motor, VDQ,Panel board)	SM-1	Knitting Master	20	Simultaneously
	To check & clean up some others M/C parts(Grease,Gear Oil push)	S.M-2	Knitting Master		
15	Setting all needle	SM-1+S.M-2	Knitting Master	70	Both work from two side
16	To keep all cambox on base & set bollt,pin	SM-1	Knitting Master		Simultaneously
	Setting all cambox	S.M-2	Knitting Master	60	

	To tight all bolt, pin properly	SM-1+S.M-2	Knitting Master		Both work from two side
17	Setting all nozzle properly	SM-1+S.M-2	Knitting Master	5	Simultaneously
18	Insert tube fabric at take down roller for drawn yarn To feed all yarn through MPF to needle through feeder & drawn yarn	SM-1+S.M-2	Knitting Master	60	Both work from two side
19	To connect MPF Belt & Line	SM-1+S.M-2	Knitting Master	5	Simultaneously
20	To knit fabric through manual drive slowly	SM-1	Knitting Master	20	Simultaneously
	To check yarn feeding on needle	S.M-2	Knitting Master		
21	To knit fabric through inch motion up to take down roller	SM-1	Knitting Master	5	Simultaneously
	To clean laid fabric & board	S.M-2	Knitting Master		
Total				500	

IV. Results and Discussions

From the table 3, we can see that there is different type of machine dia. Here most time is used in machine dia 42x24 GG.

Because there are more no. of needle, sinker, cam box, cam are used and less time used in machine dia 30X24 GG.

Because there are no. of needle, sinker, cam box, cam are less

Table 3: Result of Single Jersey Knitting Machine

Machine No.	Machine Dia	No. of Needle	No. of Sinker	No. of Cam Box	No. of Cam	Dia Wise Duration
1	30x24 GG	2260	2260	96	96	298 min
2	34X24 GG	2562	2562	102	102	320 min
3	38X24 GG	2864	2864	114	114	340 min
4	40X24 GG	3014	3014	128	128	350 min
5	42X24 GG	3166	3166	134	134	360 min

From The Table 4, we can see that there is different type of machine dia. Here most time is used in machine dia 44x18 GG.

Because there is more no. of needle, cam box, cam are used and less time used in machine dia 30X18 GG.

Because there are no. of needle, cam box, cam are less

Table 4: Result of Double Jersey Knitting Machine

Machine No.	Machine Dia	No. of Needle	No. of Cam Box	No. of Cam	Dia Wise Duration
1	30x18 GG	3390	120	240	500 mins
2	38X18 GG	4296	152	304	530 mins
3	44X18 GG	4974	177	354	550 mins

V. Conclusion

In this project, we tried to find out a standard procedure and time setting for servicing of single jersey and double jersey knitting machine. In the previous servicing method, they would take more time for servicing a knitting machine. There was no time limit as well as any standard procedure method. There was no fixed team as well as any responsible person. Here we fixed a team standard time and responsible person.

We also want to say that it's a very long term process to get the result of machine longevity but if we practice this process regularly we will be able to reduce the process loss time of knitting machine servicing.

References Références Referencias

1. Au, K. F. (2016). Advances in knitting technology. Oxford: Wood head Publishing.
2. Anbumani N. (2007). Knitting Fundamentals, Machines, Structures and Developments. New Age International.
3. Spencer, D. J. (2010). Knitting technology: A comprehensive handbook and practical guide. Cambridge: Wood head Publ.
4. Mogahzy, Y. E. (2009). Engineering textiles: Integrating the design and manufacture of textile products. Cambridge: Wood head Pub.

5. Mogahzy, Y. E. (2010). Textile design: Principles, advances and applications. Cambridge: Wood head.
6. Tobler-rohr, m. (2016). Handbook of sustainable textile production. S.L.: wood head.
7. Parts of Circular Knitting Machine and Their Function. (n. d.). Retrieved from. https ://textilelearner.blogspot.com/2013/02/parts-of-circular-knitting-machine-and.html
8. Hinds, M. D. (1985, February 17). Preventive Maintenance: A Checklist. Retrieved from https://www.nytimes.com/1985/02/17/realestate/preventive-maintenance-a-checklist.html
9. Rudnick, L. R. (2017). Lubricant additives: Chemistry and applications. Boca Raton: CRC Press.
10. Chapter, T. (n. d.). Different Parts and Function of Circular Knitting Machine. Retrieved from https://textilechapter.blogspot.com/2017/03/circular-knitting-machine-parts-function.html

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Morphological and Anatomical Leaf Characteristics of Mango Kuweni (*Mangifera Odorata* Griff*)* in Matansala and Bahoruru Villages Central Bungku of Morowali Regency

By Ardin, Ramli & Ichwan Madauna
Tadulako University, Palu

Abstract- This study aims to describe and classify the kuweni mango plants in Bungku Tengah Subdistrict especially in Matansala and Bahoruru Villages through morphological characters and leaf anatomy to look for parent trees. Observations of morphological characteristics were carried out in the villages of Matansala and Bahoruru, while leaf anatomical observations were carried out in the Laboratory of Plant Pests and Diseases, Faculty of Agriculture, Tadulako University, from December 2016 to May 2017. Observation were carried out under a microscope with a scale of 400 times magnification. After all the primary data was collected, a dendrogram analysis was performed using the SYSTAT 8.0 program. The results showed morphological and anatomical characters observed based on cluster analysis described in the form of dendrograms. Unselected accessions in the combined dendrogram are caused by the concept of distance used. In the dendrogram analysis of the distance cluster formed, it can be interpreted that the farther the distance to the right, the more various similarities of characters from the accession. Conversely, the farther the distance to the left, the more similar the character of the kuweni accession.

Keywords: mango, morphology, leaf anatomy, dendrogram.

GJSFR-D Classification: FOR Code: 070199

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Ardin [α], Ramli [σ] & Ichwan Madauna [ρ]

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I. Introduction

Mango (*Mangifera indica L*) is one type of annual plant in the form of trees originating from India. Mango is a type of tropical plant that is very popular in the world community, especially in Indonesia. These plants then spread in Southeast Asia, including Indonesia and Malaysia. This plant grows in the form of trees trunk erect, multiple branches, are shady and looked green throughout the year. The height of matures tree can reaches 10-40 meters. The age of this plant can reach up to 100 years. Morphology of mango trees consists of roots, stems, leaves, and flowers. Flowers produce seeds which generatively can grow into new plants (Pracaya, 2006).

In Central Sulawesi Province the production of mangoes in 2013 was 174,726 tons (BPS, 2013), while in Morowali District the amount of mango production in 2014 reached 17,364 tons (BPS Morowali, 2014). The low production of mangoes is due to the influence of climate, cultivation techniques and different tree conditions (Oktavianto et al., 2015).

Morowali Regency has Kuweni mango (*Mangifera odorata* Griff) or in the local language called maca mango. The obstacle in cultivating this plant because its growth very slowly, as result this fruit production also relatively low both regarding quality and quantity. Because the cultivation of mango plants is limited at home garden scale and has not been cultivated properly, besides that the quality of agriculture is not yet known. For this reason, efforts to find a parent tree that can be a source of quality seeds are very necessary. The first step required is to make morphological and anatomical observations that will be useful and provide information about the diversity of characters for future research.

II. Materials and Methods

This research will be conducted from December 2016 to May 2017, samples taken from Matansala and Bahoruru villages, Central Bungku District, Morowali Regency and morphological identification were carried out at the Tadulako University Plant and Pest Disease Laboratory.

The tools used in morphological observations are roll meters, ruler, label paper, sample plastics, digital cameras, GPS, color paint, Distance Meter smartphone applications, and writing instruments. While the tools used in leaf anatomy observation are razor blades, drop pipettes, microscopes, and SYSTAT 8.0 software. The materials used for morphological observation are intact kuweni mango plants (stems, fruits, seeds, peak) and in leaf anatomy observation, the materials used are samples of kuweni mango leaves (30 sheets the sample) and iodine dye liquid.

This research is descriptive with a direct survey method. The first activity carried out was to determine the location of the study by purpose sampling. Location determination based on the distribution of existing mango plants and information from the community

Author α: Students of Agrotechnology, Faculty of Agriculture, Tadulako University, Palu.
Author σ ρ: Agrotechnology Department, Faculty of Agriculture, Tadulako University, Palu, SoeAkarno-Hatta Street KM 9, Tondo-Palu 94118, Central Sulawesi. e-mail: ramlimohali07@gmail.com

regarding the existence of these plants, so that Matansala and Bahoruru Village in Central Bungku District were selected as the research locations. Each village selected randomly a 15 kuweni mango, and from both villages selected 30 kuweni mango plants as a sample.

The symbols use is based on the initials of the village name where the sample is located. Then sorted from 1 to 15 based on each village. Matansala Village was coded (MT), and Bahoruru Village was coded (BU). The sampled mango plants are more than 15 years old, have produced, and visually this plant is healthy, well-maintained and known by the surrounding community. After 30 kuweni mango plants selected in both of villages, then carried out gradually identification.

This morphological observation is intended to assess the diversity of accessions from samples in that location. Identified parts of the kuweni mango plant are leaves, fruit, and seeds. Visual observations were made of the size, shape, and color of the parts of the organ. Anatomical observations are intended to examine differences in leaf anatomical structure in some samples taken from the study site. The leaf parts identified were stomata density, stomata number, stomata size, stomatal index, epidermal cell size, and epidermal cell count.

Observation of leaf anatomy was carried out in the Laboratory of Plant Disease, Faculty of Agriculture, Tadulako University, Palu. Leaf samples to be observed are washed and then dried using a cloth. After that take a small part of the bottom surface of the leaves using a razor blade and then put it on the glass and given iodine liquid. Observations were carried out under a microscope with 400 times magnification scale. If the primary data was collected, a dendrogram analysis was carried out using the SYSTAT 8.0 program. This step is intended to assess the similarity between the collection of the Kuweni mangoes sample.

The part of the anatomical characters observed included the stomata index, stomata density (mm2), stomata size (μm2 length), stomata number (mm2) and epidermal cell size (length μm2).

Stomata calculation formula:

$$\text{Indeks stomata} = \frac{\text{Jumlah stomata}}{\text{Jumlah stomata} + \text{Jumlah epidermis}} X\ 100$$

$$\text{Kerapatan stomata} = \frac{\text{Jumlah stomata}}{\text{Luas bidang pandang(mm)}}$$

The similarity of all parameters observed is calculated, then clustered which has relative similarities will form a new cluster. Cluster analysis is used to calculate and determine the kinship distance between species from the data set obtained (Ripley, 1976)

Grouping is done by looking at the similarities between variables measured by euclidian distance. Euclidius distance assumes that between variables are orthogonal. The greater euclidian distance it means the number between the observation units and the smaller Euclidius distance, its means the observational units will be similar (Plotkin *et al*., 2002).

Data Analysis

This analysis is widely used to classify plants based on surveys to obtain the diversity data the specific area to compile phylogenetic trees or dendrogram.

III. Results and Discussion

Based on the dendrogram analysis of clusters in Matansala Village shows that at a distance of 0.378 there are two accessions that have the same characters namely MT13 and MT12. At a distance of 0.404, there are two related accessions namely MT6 and MT4. Furthermore, at a distance of 0.429, there are three characters that have similarities namely MT8 and MT6. At the same distance there are two accessions which still have similarities namely MT14 and MT15.

At a distance of 0.452, there are three related accessions represented by MT11 and MT13. At a distance of 0.474, there are still related accessions namely MT5 and MT1. At a distance of 0.515, there is an accession group represented by MT 5 and MT15. Distance 0.535 has several accessions that have similarities so that forming groups represented by MT13 and MT15.

At a distance of 0.571, there are several accessions that have similar representations, namely MT15 and MT2. The distance of 0.589 that are ten accessions related so that forming group, and accessions that represent the groups are MT10 and MT15. At a distance of 0.617, there are 13 accessions that have similarities represented by MT10 and MT8.

At a distance of 0.670, there are related accessions forming groups represented by MT3 and MT10. Furthermore, at the last distance of 0.685 all accessions forming one group so that the chosen accession based on morphological and anatomical characteristics in Matansala Village, namely MT3, MT9 and MT10 as shown in figure 1.

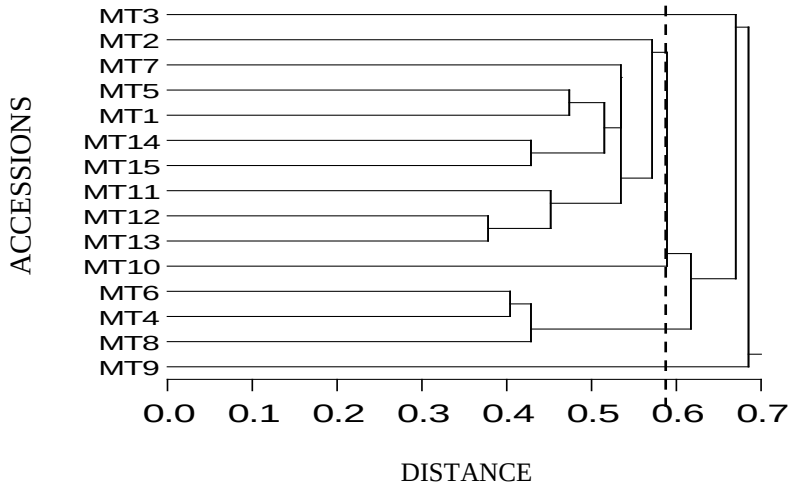


Figure 1: Dendrogram Cluster Analisys of Kuweni mango in Matansala Village

Based on the dendrogram analysis of clusters in Bahoruru Village there was a morphology and anatomy diversity of kuweni mangoes observed. Dendrogram data shows that at a distance of 0.216, there are related accessions namely BU6 and BU4. At a distance of 0.258, there are accessions that have kinship namely BU13 and BU8. At the same distance there are also related accessions, namely BU15 and BU14.

Furthermore, at a distance of 0.305, there is an accession that has a record, namely BU6 and BU3. The 0.365 distance is related to accessions, namely BU11 and BU1. At the same distance there are accession groups that still have kinship namely BU8, BU13, BU11, and BU1 which are represented by BU11, and BU13. At the same distance there are also some accessions that have a kinship, forming groups represented by BU12 and BU15.

At a distance of 0.374, there are related accessions namely BU10 and BU2. Furthermore, at a distance of 0.431 there are related accessions Namely BU7 and BU5 and at a distance of 0.447 shows that there are several related accessions that forming group (new cluster) represented by BU6 and BU11.

At a distance Of 0.457, there are several accessions that have kinship that forms groups represented by BU10 and BU6. Furthermore, at the same distance there is accession which still has a kinship that forming group represented by BU9, and BU10. And at a distance of 0.528 there are several accessions that have kinship and forming groups represented by BU9, and BU7. At the last distance of 0.577 all accessions forming one group. So that the selected kuweni mango plants based on morphological and leaf anatomy characteristics in Bahoruru Village namely BU7, BU5, and BU9, as shown in figure 2.

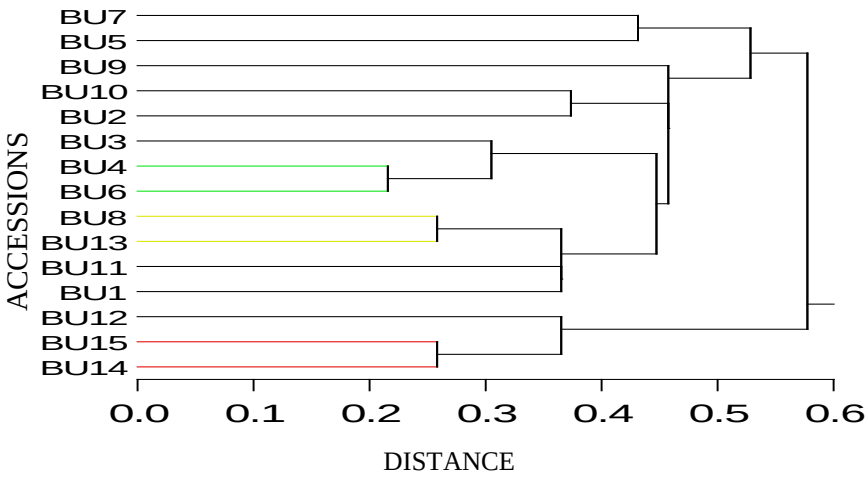


Figure 2: Dendrogram Cluster Analysis of Kuweni mango in Bahoruru village

To determine the morphological and anatomical diversity of Kuweni mango plants from both the village, then the combined cluster analysis of the Village Matansala and Village Bahoruru. Dendrogram of a cluster analysis the combined village found there are some similarities in the properties of accession Kuweni mango crop beginning of 0.216 within which there are accession-related BU6 and BU4.

At a distance of 0.258 there are accessions forming several groups, respectively is BU11 and MT14, BU13 and BU8, BU15 and BU14. At a distance of 0305 are accession forming a new cluster, represented by BU6 and BU3. The distance of 0.365 Formed several accession groups, each represented by MT1, MT10, BU1, BU13, and BU12. At a distance of 0.374, there is accession namely BU10 and BU2. At a distance of 0.403 there is an accession which forms several groups, each of which is represented by MT6, MT12, and MT6. Distance 0.431 has accession that has similarities, namely BU7 and BU5. At a distance of 0.447 several accession groups are formed, each represented by MT2, MT15, MT12, MT13, BU6, BU10, and BU3. Furthermore at a distance of 0.482 there are several accessions which forming the group represented by MT6 and MT5.

At a distance of 0.506, there is an accession that forming a group namely MT7 and MT6. Furthermore, at a distance of 0.528, there is an accession group represented by BU7 and MT7. Then at a distance of 0.577, there is an accessions group represented by BU12 and BU7. At the last distance of 0.648, all accessions become one group. Therefore the accession was chosen based on the analysis of the combined clusters of both villages, based on the morphological and anatomical characteristics of kuweni mango leave in this villages are BU9, MT5, MT7, and MT3 as shown in the following illustration (Figure 3).

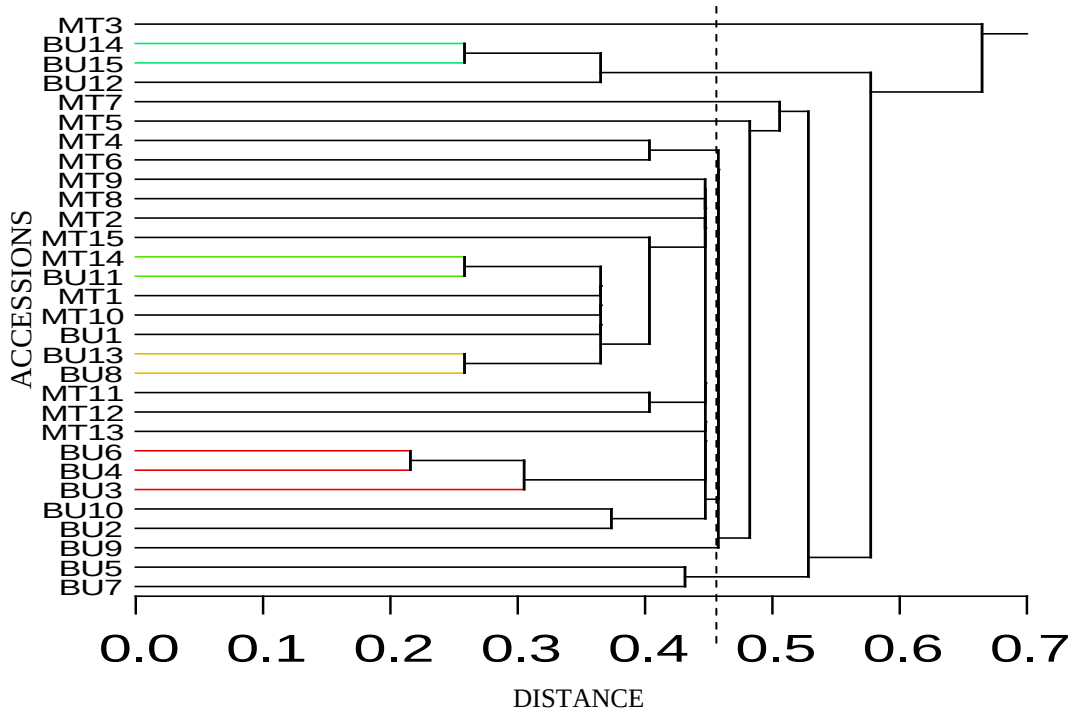
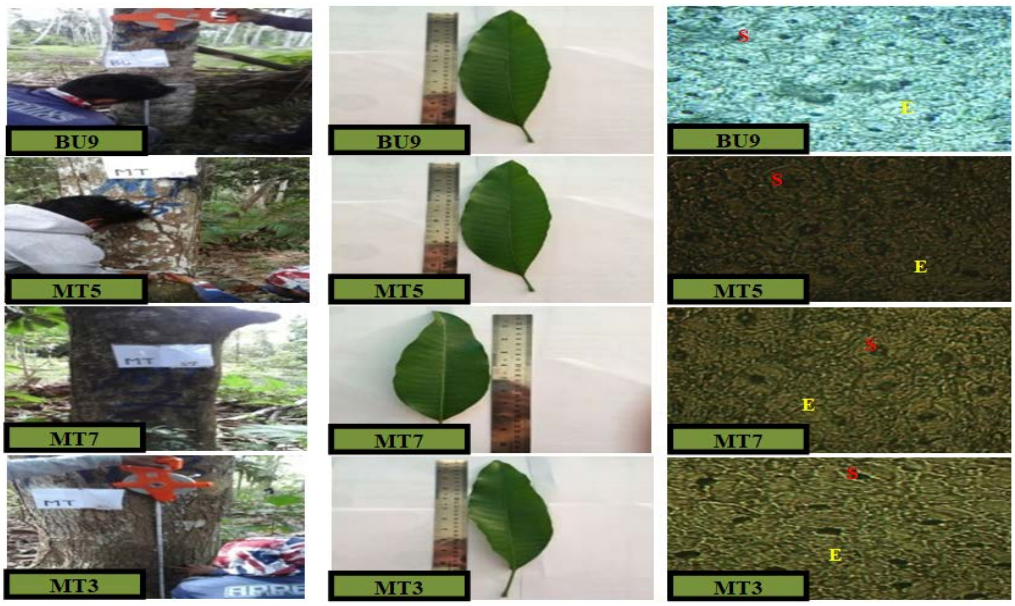


Figure 3: Dendrogram clusters analysis of Kuweni mango in Matansala Village and Bahoruru Village

The distinguishing characteristics of the four accessions chosen from the combined cluster analysis of both villages are presented in the following figure.



Notes: ***S*** *=Stomata,* ***E*** *= Epidermis, Magnification (400 times).*

Figure 4: Morphological and anatomical Identification of mango leaf based on stems morphology, leaves and leaf anatomy on accession BU9, MT5, MT7, and MT3 in the Matansala and Bahoruru village

Based on cluster analysis results on both villages represented by 30 samples, four accessions of the kuweni mango were selected as agriculture, namely BU9, MT5, MT7, and MT3. The accession choice is influence with the concept of distance used in the cluster analysis dendrogram. The farther distance formed on the dendrogram, its means smaller the similarities of the accession. According to Hendrawan (2004) in Hukmaeni (2011), if there are significant differences in the cluster, the sample will separate.

In dendrogram analysis can be defined distances farther than the distance to the right hand, the more diverse the similarity character of accession. More than the distance to the front left, the similarity character of accession to the kuweni mango. (Saparni, 2008) revealed that similarity is expressed as a percentage, 100% which means exact or perfect while 0% is equally different.

Dendrogram cluster analysis on a combination of both the village there is two accessions resurfaced from each village. In Matansala village, MT3 accession appeared on the both on special dendrogram in Matansala Village and dendrogram of the villages combined. While in Bahoruru villages, BU9 accession appeared both on special dendrogram in Bahoruru Village and dendrogram of the villages combined.

This accession emergence because that previously MT9 and MT10 appeared in the dendrogram Matansala village has similar characteristics with the accession in the Bahoruru Villages after a cluster analysis in both villages. Likewise in the accession of BU5 and BU9 which previously appeared in the dendrogram Bahoruru Village has the same character as the accession in Matansala Village after a cluster analysis in both villages.

Accession MT9 has a similar characteristic with the accession BU10 and BU12 are shown at 0.447 distance on the dendrogram of the villages combined. Whereas accession MT10 has similar characteristics with the accession BU1 shown at 0.365 distance on the dendrogram of the villages combined. For accession BU5 and BU7 have similar characteristics to the accession MT13, MT2, MT8, and MT9 shown at 0.431 distance. Therefore accession MT3 and BU7 appeared twice both on dendrogram each village and dendrogram combination both of villages.

The results showed that the oldest and the youngest kuweni mango plants, respectively MT3 (23 years) and BU9 (21 years). The highest plants of the four selected accessions MT3 (20.2 m) and the lowest BU9 (18.23 m). The observation found that the widest trunk circumference is MT7 (124 cm) and the smallest is BU9 (88 cm), while the canopy shape of the four accessions has the same oval shape.

The observation also found that the trunk color of local kuweni mango from the four chosen accessions had the same light brown color. This means that morphological characters are easily seen so that the variations can be assessed quickly compared to other characters. A good taxon restriction is done using hidden characters (Stace, 1981).

Forms of kuweni mango leaves contained in the research area largely elongated and has a length of leaves about 2½ x width, leaf tip chartaceous (taper)

with the surface of the leaf discount slippery coating, the basic form of the leaf that is acute (sharp) and color petioles (stalks) light green, broad and long petioles and leaf curvature varies, the color flush reddish brown and light green. Anatomically, the leaves are very varied and provide plenty of real character systematically (Stuessy, 1990).

Tjitrosoepomo (2009) argued that the color leaves of plants species may change according to circumstances where the growth and intimately linked with water and food supplies as well as radiation and generally the leaves color on the top and bottom is obviously different, Usually the upper side is greener, slippery, or shiny when compared with the bottom side. Some mango plants have varying leaf color, leaf color and shape differences are because the external influences such as the environment where the plants grow (Sadri, 2016).

Stomata located on the leaf surface, but is most commonly found on the surface of the bottom leaf (Pracaya, 2011). Anatomical observations of four selected mango accessions showed accession BU9 have the largest stomata size is 0.259µm with the sum of stomata 72/mm^2 while the smallest stomata are contained in the accession MT7 is 0.177µm with the sum of stomata 100/mm^2.

The epidermis is the layer outermost cells and covers the surface of leaves, flowers, fruits, seeds, stems, and roots. The epidermis serves as a protective inner organs in plants. Based on ontogeny, epidermis derived from meristematic tissue which protoderm (Sumardi and Pudjoarinto, 1994).

According to the function, shape, size, and arrangement of epidermal cells are not the same or different in various types of plants, as well as the form or stomata type. Although the epidermis is different, it all arranged tightly together and form dense buildings without inter-cell space (Woelaningsih, 2001).

The epidermal observations of the four selected accessions showed that BU9 accession had the largest epidermal size of 0.504μm with an epidermal number of 82/mm^2, MT3 of 0.203μm with epidermis number 128/mm^2, then MT7 had an epidermal size of 0.164μm with epidermis number 120/mm^2, while the smallest epidermal size was found in MT5 accession is 0.138μm with an epidermis number 160/mm^2.

According to Miskin *et al*., (1972) plants that have a high stomata density will have a higher transpiration rate than plants with low stomata density. The results showed that the stomatal index BU9 0.467 with 24 mm^2 stomata density, MT7 0.454 with 33.33 mm^2 stomata density, MT3 0438 with 33.33 mm^2 stomata density and MT5 0310 with 24 mm^2 stomata density.

Levit (1951) states that many factors influence plant resistance to drought including a tendency to slow dehydration such as efficient absorption of surface water and water conduction systems, leaf surface area and structure. This shows that stomata density may affect two important processes in plants, namely photosynthesis, and transpiration.

Of the four accessions of kuweni mango selected from the two villages, the accession MT5 has an index of stomata and stomata density smallest of the three other accessions. Thus accession MT5 allegedly resistant to dry environmental conditions. However, to determine the agriculture not only seen from morphological and anatomical characters of leaf accession. Therefore is a need advanced research to support the election of the agriculture Kuweni mango plants particularly in Matansala and Bahoruru Village Central Bungku of Morowali District.

IV. Conclusion

Kuweni mango selected in the Matansala village namely accession MT3, MT9, and MT10. While the crop elected in the Bahoruru village namely accession BU7, BU5, and BU9. The kuweni mango selected as the agriculture of both village dendrogram namely BU9, MT5, MT7, and MT3.

Accession of MT9, MT10, BU5, and BU9 is not selected because the four accessions have similar characters in the combined dendrogram of Matansala and Bahoruru Villages based on concept distance dendrogram cluster analysis concept. In this concept a distance formed can be interpreted that the farther the distance to the right, the more diverse the character resembles the accession. conversely, the farther the distance to the left, the more similar the character of the kuweni mango accession.

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References Références Referencias

1. Central Agency of Statistics, 2013. Central Sulawesi Province in Figures. Accessed on February 12, 2016.
2. Central Agency of Statistics, 2014. Morowali Regency in Figures. Accessed on November 30, 2015.
3. Hendrawan, A., 2004. Identification of Morphological and Genetic Diversity of Mangoes. [Essay]. Faculty of Agriculture, UGM, Yogyakarta
4. Hukmaeni, 2011. Characterization of Stem Morphology and Leaves of Mangosteen (Garcinia mangostana L.) in Banggai Kepulauan Regency. [Essay]. Department of Agriculture, Faculty of Agriculture, Tadulako University.

5. Levit, J. 1951. Frost, Drought and Heat Resistance. Annual Review of Plant physiology 7 (2): 245-268.
6. Miskin, E.K., D.C. Rasmusson, and D.N. Moss. 1972. Inheritance and Physiological Effects of Stomata Frequency in Barley. Crop Science 12: 780-783.
7. Oktavianto, Y., Sunaryo and A. Suryanto, 2015. Characterization of Mango (Mangifera indica L.) Cantek plants, Ireng, Empok, Jempol in Tiron Village, Banyakan District, Kediri Regency. Journal of Plant Production, 3 (2): 91-97
8. Plotkin, J. B., J. Chave and P.S. Ashton, 2002. Cluster Analysis of Spatial Pattern in Malaysian Tree Species. The American Naturalist. 16 (5): 629-644.
9. Pracaya. 2006. Planting Organic Vegetables in Gardens, Pots and Polybags. Self Help Spreader. Jakarta.
10. .2011. Plant Mango in The Garden and Pot With an Organic System. Self Help Spreader. Jakarta.
11. Ripley, B.D., 1976. The Second-Order Analysis of Stationary Point Processes. Applied Probability J. 13: 255-256.
12. Sadri, M., 2016. Identification of Morphological Characteristics and Anatomy of Local Mangoes (Mangifera Spp.) Morowali in Bente Village and Bahomoleo Village, Central Bungku District. [Essay]. Department of Agriculture, Faculty of Agriculture, Tadulako University.
13. Saparni, S. 2008. Identification of Morphological Properties of Jatropha (Jatropha curcas L.) Javanese accession in Pakuwon's fence. [Essay]. UNS Faculty of Agriculture. Surakarta.
14. Stace CA. Plant Taxonomy and Biosystematics. Edward Arnold, London. 1981.
15. Stuessy, T.F .. 1990. Plant Taxonomy - The Systematic Evolution of Comparative Data. Columbia University Press, Columbia. p. 267-270.
16. Sumardi I, Pudjoarinto A., 1994. Structure and Development of Plants. Faculty of Biology UGM, Yogyakarta.
17. Tjitrosoepomo, G., 2009. Plant Morphology. Gadjah Mada University Press, Yogyakarta
18. Woelaningsih, S., 2001. Structure and development of plants II. Faculty of Biology UGM, Yogyakarta.

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Can Elephants and Livestock Co-Exist?:Solving Grazing Conflicts through Adaptive Collaborative Management in Southern Kenya

By Peter Kamau

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Keywords: kenya, elephants, livestock, conservation, political ecology, maasai. adaptive collaborative management.

I. Introduction

Conflicts between pastoralists and protected area managers are long standing and widespread in the rangelands of East Africa (Homewood and Rodgers 1991; KWS 2014; Lore and Mulder 1999; Neumann 1997). Most of these conflicts occur in arid and semi-arid areas. For many generations, East African pastoralists utilized arid and semi-arid areas to produce livestock products for subsistence, trade and cultural purposes (Herskovits 1926). For these people, access to critical livelihood resources such as water and grazing pastures has always been vital. In the past, these groups relied on livestock mobility and communal management of natural resources to sustain their livestock and their livelihoods. Pastoralists and their livestock used the same lands with wild animals with minimal conflict. However, this ancient tolerance of wildlife by pastoral communities is under threat. Growing human population and the introduction of new land use such as farming and wildlife conservation in pastoral rangelands have increased competition for water and pastures among people, livestock and wildlife.

Political ecologists among other scholars have focused on the interactions between pastoralists and their environments in East African savannahs (Homewood and Rogers 1991; Little 1996; Neumann 1992, 1998). Most studies indicate a long history of pastoralist activities in these savannahs and emphasize the manipulation of savannah vegetation through grazing and burning (Laris 2006; Sheuyange*et al.* 2005). Despite studies that show the ecological benefits of livestock grazing in East Africa rangelands (Reid 2012; Western 1994), there is a still widespread perception that livestock grazing is inherently detrimental to savannah landscapes. Arguably, this perception emanates from ideas such as the "tragedy of the commons" (Harding 1968) which holds that individuals acting in their own self-interest will tend to overuse a common resource, thereby depleting the resource and consequently hurting all the users.

In East Africa, the "tragedy of the commons" paradigm has provided a strong rationale for governments efforts to protect natural habitats and "wilderness" from anthropogenic disturbances. Since the 1940s, former grazing lands and drought refuges have been given protected area status such as national parks, thus excluding any use by livestock within them (Brockington 2005; Neumann 1998). In the post-colonial era, development efforts in pastoral areas focused on the establishment of group ranches. These group ranches, which confine pastoralists to particular blocks of land, do not provide adequate gazing resources, especially in drought periods.

Also popular, is the equilibrium view of East African pastoral systems and the widely held perception that these stable systems are under threat from overstocking and other human activities which destabilize the equilibrium. Ellis and Swift (1988) examine this view in detail. Proponents of the equilibrium view recommend the reduction of livestock numbers and other measures such as eliminating fires from

Author: e-mail: wakamau2011@gmail.com

savannah ecosystems in order to return them to stable states (Johnson and Tothill1985; Walter 1971).

However, the tragedy of the commons and equilibrium theories have been discredited. Scholars have pointed out that Harding was confusing commons with a "no-man's land" with no boundaries and rules for access. In a strong critique of the tragedy of the commons theory, Ostrom (1990) has argued that local people often come up with solutions to the commons problems, but when common resources are taken over by extra local forces such as the state, those solutions do not work (Ostrom 1990). Non-equilibrium theories have replaced equilibrium views of savannah ecosystems. In non-equilibrium paradigms, change and not stability is thenorm in savannah ecosystems, and disturbances including human induced fires and livestock grazing have played an important role in the evolution of savannahs (Dublin 1995).

Other studies have rejected simplistic assumptions about the negative impacts of pastoralism on savannah landscapes and suggested that herding is often compatible with wildlife. For example, Reid (2002) has shown that livestock grazing enriches East African savannah landscapes and is important for biodiversity. Other studies have found that grazing reduces fire fuel loads and therefore lowers fire frequency and intensity (Roques*et al*. 2001; Ward 2005). Augustine (2003) found that livestock grazing promotes the redistribution of nitrogen and phosphorous in soils and plants. These studies suggest that livestock can have positive impacts on savannah ecosystems.

In Kenya, conflicts between pastoralists and conservation authorities have received significant attention from scholars (Norton-Griffiths 2000; Oketch 2010; Waweru and Oleleboo 2013). However, the bulk of research conducted in Kenya on these conflicts, has given little attention to the role played by African elephants in shaping these conflicts. On the one hand, elephants are the most important tourist attraction and therefore the center of conservation efforts in Kenya. On the other hand, elephants pose a threat to pastoral peoples' lives and livelihoods. The conflict between tourism and pastoralism is exemplified in the Tsavo landscape in southern Kenya. Tsavo hosts the largest concentration of elephants in East Africa and is key to Kenya's tourism industry. Although livestock grazing is outlawed in all national parks in Kenya, local people occasionally graze their livestock illegally in Tsavo parks (Tsavo West, Tsavo East and Chyulu Hills National Parks), thus causing tension between local pastoralists and the Kenya Wildlife Service (KWS). KWS is the state agency responsible for managing national parks in Kenya.

Grazing in national parks by the local Maasai has been a controversial issue since the establishment of the Tsavo West National Park in 1948. Past and current government officials have blamed the Maasai herds for competing with wildlife for grazing resources in the national park especially during the dry seasons. The District Commissioner in Kajiado lamented in a 1964 report:

> Furthermore, when the Maasai were desperate for grazing in the drought of 1961, they claimed that most of the western section of the park (Tsavo West) was their traditional dry-weather grazing, and in spite of strong protests by the trustees they invaded many thousands of acres and plundered most of the grazing which was equally necessary for wild animals.
>
> [May 1964. KL/1/32].

Recently, the KWS blamed the decline of hippopotamus in Mzima springs on livestock grazing in Tsavo West National Park. The Chairman of KWS, Dr. Richard Leakey, said in an interview;

> The domestic stock took most of the grass and pushed the wildlife further and further into the heart of the park and by the time the hippos get out to feed, they find the grass is gone. If we had kept cattle out of the park, which we must do if we want a national park, that would not have happened[January 2016 interview with a Kenyan television channel, Nation TV].

Each year, KWS spends a significant amount of resources to apprehend herders and drive out livestock that encroaches into the parks. However, elephants continue to use lands adjacent to national parks for water, browse and dispersal to other areas. This generates conflict between KWS and local people and also undermines opportunities for collaboration.

This political ecology study focused on the Maasai people who are residents in three group ranches located in the region west of Tsavo West and Chyulu Hills National Parks. This chapter will refer to the research subjects as the Maasai of Tsavo. The Maasai living in the three ranches are a microcosm of the larger Maasai cultural group that forms about 2.5% of Kenya's total population of 44 million people.

The study employed the framework of political ecology to achieve two research objectives. First, it sought to better understand the perspectives of the Maasai of Tsavo on the role and impact of livestock on local livelihoods. Secondly, this research explored how local knowledge of livestock management can contribute to a collaborative grazing management plan that solves grazing conflicts between the Maasai and KWS. Political ecology has traditionally paid attention to how resource conflicts are mediated between and among social groups, with unequal power (Escobar 1995; Ndi and Batterbury 2017; Watts 1983). This study hypothesizes that solving grazing conflicts in the study area will promote elephant conservation. The study employed an applied research design that supports Adaptive Collaborative Management (ACM) and aims at creating knowledge sharing opportunities between local people and park authorities regarding livestock grazing and elephant conservation. The ACM approach is based

on the premise that there are no strict instructions regarding natural resource management. ACM assumes that knowledge about how socio-ecological systems work is never adequate and recognizes the need for adaptive learning processes that accommodate local knowledge in conservation decision making (Olsson and Folke 2001; Sluyter 2002).

II. Study Site and Methods

a) Study area: Geographic setting

This study was conducted in Maasai villages adjacent to the western boundaries of Tsavo West National Park (TWNP) and Chyulu Hills National Park (CHNP), in southern Kenya (Figure 1).

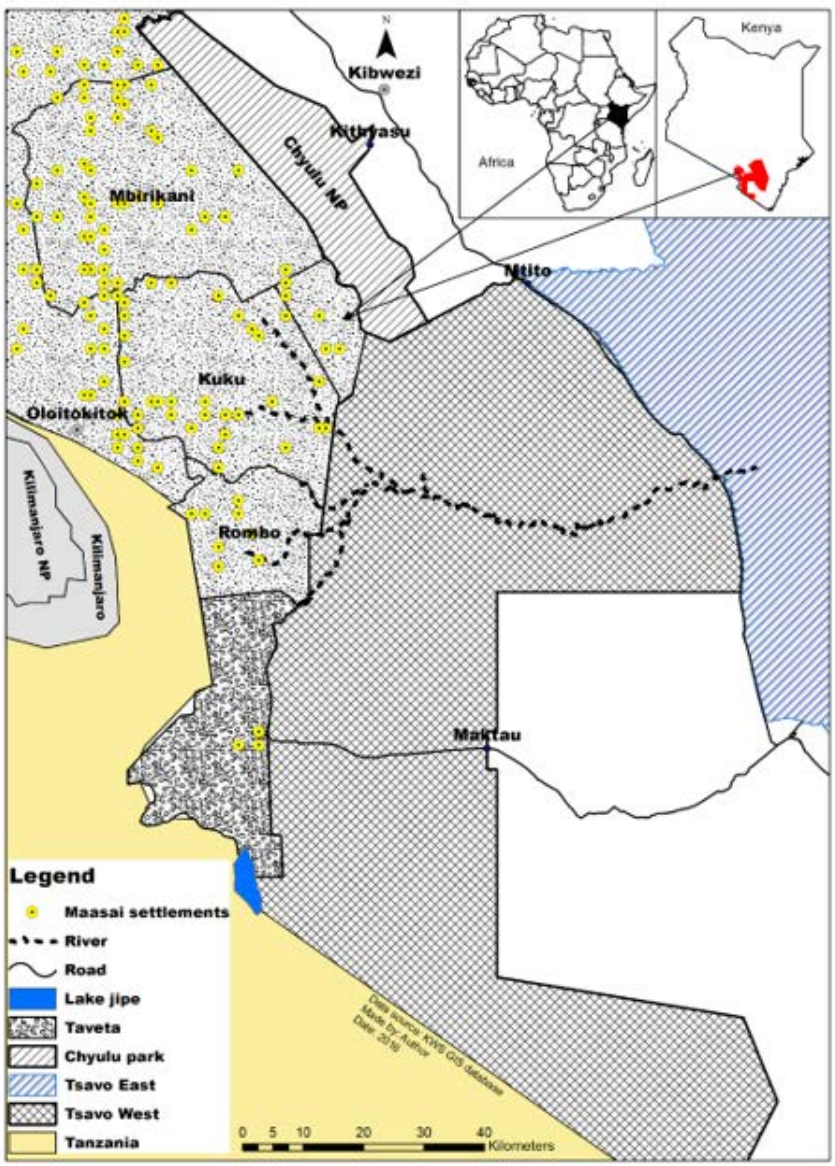

Figure 1: Location of study villages in Mbirikani, Kuku, and Rombo group ranches in southern Kenya

The study villages are within the Mbirikani, Kuku and Rombo group ranches and fall within a 20 km buffer zone from the CHNP and TWNP boundaries. This area is approximately 5,000 km^2 and falls within Kajiado county in Kenya. The general topography of the area is low and flat, but the north of the study area lies on the western slopes of Chyulu Hills and is hilly. The study area is arid to semi-arid. The rainfall pattern is bimodal: about 200-600 mm of precipitation fall during the long rains (March-May), and 300-700 mm during the short rains (November and December). Higher elevations in areas near the ChyuluHills, receive more rainfall and have cooler temperatures. Acacia-Commiphora savanna is the most dominant vegetation type in the study area. This Acacia-Commiphora savanna comprises varying densities of trees and shrubs, open grassland, woodlands, scrub, and thicket. Montane evergreen forests also occur on the spine of the Chyulu Hills.

The study area is 85-100% arid and semi-arid (ASAL) and about 40 % of resident population live below the poverty line-less than $ 2 a day (ROK 2013). Droughts are recurrent in this area; livestock mortality is

common during drought periods (Nkendianyee*t al*. 2011). Despite the arid conditions, the area has a unique grassland landscape that supports a variety of wildlife species including the iconic "big five": The African elephant *(Loxodontaafricana*), the African buffalo *(Synceruscaffer*), the African lion (*Pantheraleo)*, the African leopard (*Pantherapardus*pardus), and the black rhinocerous (Dicerosbicornis). People, wildlife, and livestock (Figure 2) compete for scarce pastures and water in the semi-arid area sometimes resulting to conflicts.

Figure 2: A Maasai herder in Mbirikani group ranch drives his herd home after a day in the pastures. Photo taken on July 17, 2016

The three group ranches in the study area are also a wet season dispersal area for wildlife in Amboseli National Park, West of CHNP, and other parks in Tsavo. As a critical habitat for endangered plant and animal species, the area receives immense attention globally for tourism, scientific and conservation reasons. Two high-end lodges among other tourist facilities are found on the western slopes of the Chyulu Hills. These facilities create jobs for local people and generate revenues, some of which are reinvested in conservation and community projects. There is also a predator compensation scheme in the area funded by Western donors which pays for livestock killed by wildlife, especially lions.

b) People and land resources

The study area is traditional land of the Maasai who lived a transhumant lifestyle before the advent of British colonialism in Kenya in the 1890s. Traditionally, the Maasai relied solely on a subsistence economy of keeping livestock. Livestock was owned by individual families and livestock products including meat, milk and blood were the staple foods of the Maasai. Other than being a source of food, livestock also played an important social and political role among the Maasai. Even today, livestock is an important measure of wealth and social status and also a medium of exchange. For example, cows may be used to pay dowry to a bride's family. Individual, family or clan ties are strengthened by using livestock as gifts. For many generations, land tenure in the study area was communal; the Maasai had institutions and practices that allowed for extensive livestock grazing. Seasonal migration with livestock ensured their survival even during extreme dry seasons. Recently, a few Maasai residents have begun engaging in small scale farming in the group ranches. However, the bulk of food consumed in the study villages (maize,

rice, cabbage) is grown by non-Maasai immigrants from other parts of Kenya who cultivate fertile areas around Loitoktok town (Ntiati 2002). The Maasai living in the study area are also gradually venturing into small scale businesses such as shops and restaurants, selling milk locally and also selling beads, masks and carvings to tourists.

The traditional grazing range for the Maasai has, however, shrunk due to the introduction of new land usesin their traditional lands (Bekure and de Leeuw 1991). Wildlife conservation as a land use reduced grazing areas for the Maasai. Tsavo West National Park was established in 1948 under British colonial rule. Chyulu Hills National Park was gazetted in 1983, two decades after Kenya attained independence. The boundaries for these parks were drawn without adequate consideration of Maasai movements during the dry seasons. The boundaries also blocked routes used by the Maasai to trade with their agro-pastoral eastern neighbors, the Kamba.

In the 1970's, the Kenyan government began a program in pastoral rangelands to replace communal ownership of land with private land ownership in the form of individual and group ranches (Ntiati 2002; Campbell *et al*. 2003). Group ranches were introduced in the study area to sedentarize the Maasai and modernize livestock production. Mbirikani, Rombo and Kuku group ranches were established in 1981, 1973 and 1975, respectively, and currently have an estimated 87,000 head of cattle (Table 1).

Table 1: Showing human and livestock population in Mbirikani, Kuku, and Rombo group ranches

Group Ranch	Area in Sq km	Human population	Persons per Sq km	Heads of cattle (2016)	Date of establishment
Mbirikani	1228	10225	8.32	25,000	1981
Kuku A and B	1446	11200	7.74	17,000	1975
Rombo	526	21510	41.12	45,000	1973
Total	3200	42935		87,000	

Human and livestock population data extracted from reports by Kenya National Bureau of Statistics, and Kajiado County Integrated Development plan, 2013-2017

There are other Maasai group ranches, which fall outside the study area. Group ranches are managed by a committee elected by group ranch members. Due to modernization pressures, the group ranches are facing the threat of subdivision. Some local Maasai, especially young men, are frustrated with the way group ranches are run and prefer to have their own parcels of land rather than a share of family land.

For cultural reasons, gender inequality in the study area is still prevalent. During this study, we found that the level of illiteracy among middle aged women was higher than that of men. Property ownership, especially cattle was for the most part vested in men who head the majority of households in the area.

c) Methods

The purpose of this study was to explore how local views about livestock grazing among the Maasai living adjacent to TWNP and CHNP can contribute to an adaptive management plan with the KWS. To achieve this objective, field research was conducted in different periods: June to August 2012; June to August 2015, December 2015 to January 2016. The research covered 6 villages stratified north to south in Mbirikani, Kuku and Rombo group ranches occurring within a 20 km buffer zone from CHNP and TWNP (Fig 1). During the research periods, twenty-four in depth interviews were conducted with key informants: two men, and two women from each of the 6 villages. I also held one focus group meeting in each of the six villages. Each focus group meeting comprised of five men, and five women (n = 10 for each group, total = 60 participants). Local administrators (chiefs and assistant chiefs) helped to select participants from their villages. Participants in interviews and focus group meetings were asked for voluntary consent; they were also assured that any information they shared would not identify them as individuals or their villages. Interviews with key informants involved four key research questions (Table 2) that focused on their perspectives on livestock grazing and land conditions in their villages.

Focus group meetings explored how the knowledge shared by the key informants might contribute to an adaptive co-management plan with the KWS with respect to livestock grazing. All the meetings started by introducing the concept of Adaptive Collaborative Management (ACM). During focus group meetings, some of the data gathered during interviews with key informants was shared and discussed. Two open ended questions guided focus group

meetings:1.,What information on livestock grazing do you want to share with KWS? 2., How will an adaptive co-management plan with KWS resolve grazing conflicts and promote elephant conservation? I moderated the meetings, which took about three hours on average. I also gave equal opportunities for participation by both genders and representatives across the three ranches. Discussions were held in Swahili and local research assistants helped translate from Maasai to Swahili and vice versa where necessary. Formal interviews were also held with four senior park officials in TWNP and CHNP. The officials are employees of the KWS who are conversant with park laws and regulations.

Table 2: Key research questions and type of data collected

Key research question	Type of data collected	Tool used
What is the importance of livestock in your household?	Reasons for owning livestock and the economic and cultural uses of livestock.	Interviews with key informants
Where do you graze your animals during the wet and dry seasons?	Areas where local residents take their animals to graze according to seasons.	Interviews with key informants
What grazing concerns/information would you like KWS to know?	Issues about livestock grazing	Focus group discussion with Maasai participants.
What are your views about an ACM KWS that resolves grazing conflicts and promotes elephant conservation?	Views on how local people and KWS can collaborate to resolve grazing conflicts	Focus group discussion with Maasai participants.

III. Results

a) Interviews with key informants

Interviews with key informants who are village residents in the Mbirikani, Kuku, and Rombo group ranches revealed a strong attachment to their landscape and cattle. Cattle are an important element in the culture of the Maasai, and the "Cattle complex in East Africa" described by Herskovits (1926) cannot be overemphasized among the people I interviewed. Eighteen out of the twenty-four key informants interviewed (75%) reported that they owned at least ten heads of cattle. Key informants gave seven key reasons why livestock ownership is important for their livelihoods (Table 3).

Table 3: Key reasons for owning livestock reported by Maasai informants and ranked by the total number of key informants (men and women) who mentioned each reason

Reasons for owning livestock	Men key informants (out of 12 men)	Women key informant (out of 12 women)
1. For food (milk and meat).	12	12
2. For income for other daily needs.	12	12
3. Cultural tradition (Maasai should own cattle).	12	8
4. Land conditions suitable for livestock rearing.	10	8
5. For marriage ceremonies (to pay for brides).	8	6
6. As a form of wealth, security/safety net).	7	4
7. For circumcision ceremonies (food, gifts).	6	5

According to both men and women key informants, the most important reasons for owning livestock was food and nutrition (milk and meat) and a source of income for daily food needs. The majority of participants reported that income from livestock and livestock products, especially milk, is used to purchase other foods, mainly maize and beans. Income from livestock was also reported to serve for other non-food needs such as buying clothes, books and school fees for school children. Women participants highlighted the importance of livestock in providing income to meet emergency needs. Seven out of twelve women (58%) mentioned that they sell their goats to pay for health care when their children get sick. It was also clear from

narratives that while men are ordinarily the owner of livestock in male headed households, women milk cows and have more control over the sale of milk. Cultural reasons for owning livestock were also reported by the majority of informants who said that owning cattle is a moral responsibility of the Maasai. Eleven out of all twelve men interviewed mentioned this reason as compared to eight out of all twelve women interviewed.

The arid and semi-arid conditions of the area that are more compatible with pastoralism than other land uses were also mentioned as a main reason residents own livestock. Participants emphasized that livestock grazing is more sustainable than farming in the group ranches. Other reasons mentioned include the use of livestock as social security and ceremonies such as marriage and circumcision events. Perhaps due to cultural reasons, male interviewees gave more reasons than did women; men also seemed to have well-rehearsed talking points about the questions asked. Generally, key informants, both men and women had sufficient knowledge of local issues, and their insights helped the researcher shape the agenda of focus group discussions.

b) Local perspectives on grazing

I asked key informants about their activity schedules and seasonal calendars to show where they graze their animals at certain periods of the year (Table 4). There was considerable consensus among different informants about grazing patterns in the landscape. Responses given by local pastoralists suggest that their livestock production system depends on herd mobility.

During the wet season, most of the livestock is grazed in the ranches. At the beginning of the dry season, livestock is moved to areas with higher herbaceous biomass. The are as most relied on during the dry seasons are the higher elevations on the slopes of the Chyulu Hills. The hills experience higher rainfall than do lower elevations in the group ranches where permanent settlements are located. It was clear from narratives by key informants that the Maasai perceive the green undulating Chyulu Hills as an area with high grass biomass and a grass bank for their livestock during the dry season. The hills are free of tsetse flies and are less prone to serious cattle diseases such as East Coast Fever. One male participant who was forceful and articulate said:

> The only place where grass does not get depleted is Chyulu Hills. We prefer grazing our animals in the hills from October to December, during this time the grass has a "high libido" effect on bulls. This causes intense mating between bulls and cows in the hills and this increases the chances of getting new born calves in the following wet season. Also, due to higher levels of moisture in the hills, animals can survive for 12 days without being supplied with water. [December 5, 2015].

Table 4: Common grazing locations through a calendar year in the study area

Season	Areas commonly grazed	Explanation
Jan- April	Group ranches in study area, at the foot and western slopes of Chyulu Hills	This is the middle of the wet season and there is grass in the hilly areas of the ranches. If the rains are good, and there is enough grass in ranches, animals are moved to lowland pastures
May- June	Group ranches in the study area	This is the beginning of the dry season. Most livestock are in the ranches, when new calves are born
Jul –Sep	Ranches in the study area. Other neighbor ranches	This is during the dry season and pasture in ranches begin to decline Livestock is gradually moved to other group ranches around Amboseli National Park and later to CHNP and TWNP
Oct-Dec	CHNP, TWNP, ranches around Amboseli	The short rains begin, very little grass is available in ranches. The parks have nutritious grass that has a high libido effect on bulls, this increases mating

CHNP- Chyulu Hills National Park
TWNP- Tsavo West National Park

Other than the Chyulu Hills, livestock is also taken to other lands including parts of Tsavo West National Park and Kiboko Range Research Station. The Maasai also move their livestock to other ranches adjacent to the Mbirikani, Kuku, and Rombo group ranches. Local narratives indicate that the Maasai would like to have access rights to pasture and water resources in protected lands which they referred to as former "Maasai grazing lands". Interviews with local informants also revealed a culturally grounded understanding among the local people that, during dry seasons, livestock owners should be allowed access to other grazing lands in order to sustain their herds. A woman informant said: "We know that the park belongs to the government and we are not allowed to graze in the parks but we request that when we exhaust grass in the ranches, the government should open up the park for the Maasai to graze."

Local informants gave a nuanced explanation of the relationship between the Maasai, livestock and wildlife. Nineteen out of the twenty-four informants (79%) mentioned that since elephants and other wildlife graze on pasture in the Maasai owned ranches during the wet season, livestock should also be allowed into the parks during the dry season. It was clear that this mutual reciprocal right of use is a customary practice whereby the local Maasai allow user rights of their resources to those who also extend them the same rights. Furthermore, local ecological wisdom holds that while individuals own the livestock; the land, pasture and wildlife are the collective property of the community. One man who is also a local administrator argued:

> We the Maasai regard the animals including elephants, leopards and lions as part of our environment, these animals are our property. We have lived with these animals and we have protected them in so far as they do not threaten our lives and that of our livestock. If you look at the area between Tsavo and Amboseli, there are many animals outside the park sharing pasture with livestock. KWS should allow us to graze in the parks in the dry season when we exhaust grass in the ranches. If they don't care about our cows, why should we care about theirs? But if there are people with too many animals, they should only be allowed to bring a limited number of animals into the park. [December 8, 2015].

Three Maasai informants also mentioned that livestock grazing was an important check on fires. They explained that grazing prevents the accumulation of dry grass and other fuel over large areas. They noted that high fuel loads in the Chyulu Hills often result in high intensity fires that negatively affect wildlife and vegetation.

c) *Focus group meetings and ACM as a planning strategy*

I used focus group meetings withMaasai village representatives and interviews with officials of the KWS to gather views on the possibility of employing the co-management approach to solve grazing conflicts in Tsavo. This research hypothesized that solving grazing conflicts would ensure more cooperation in elephant conservation between the Maasai and the KWS. Two focus group meetings were held in each of the three group ranches. Each of the six meetings consisted of five men and five women local participants. The researcher moderated the discussions and ensured equal participation by both genders. The concept of ACM was introduced to the participants in Swahili, a language that most participants understood.

Participants were given an opportunity to ask questions in order to clarify the concept of ACM. At first, participants asked questions revolving around the relationship between local people and KWS. For example, one participant wondered why KWS responded quickly when a wild animal is killed by poachers or dies of other means while showing a slow response when a villager is attacked by wildlife. I explained that ACM has the potential to address such questions because it supports dialogue and information sharing among stakeholders. I also further explained the meaning and goals of ACM.

To set the tone for the discussion, participants in focus group meetings were also asked to rank the major reasons for livestock ownership given by key informants. All the seven reasons were read and displayed on a manila paper. Participants were given twenty minutes to discuss amongst themselves and rank the seven reasons by consensus. The most important reason was assigned rank one while the least important was assigned rank seven (Table 5).

Table 5: Reasons A-G for owning livestock as ranked by Maasai participants in 6 village focus group meetings. Rank 1 is assigned the most important reason while rank 7 is assigned the least important reason.

Village focus group	Rank 1	Rank 2	Rank 3	Rank 4	Rank 5	Rank 6	Rank 7
# 1	A	B	D	C	E	G	F
# 2	A	B	C	D	F	E	G
# 3	A	B	D	F	C	E	G
# 4	A	B	D	C	E	F	G
# 5	A	B	F	C	D	E	G
# 6	A	B	C	F	E	G	D

(A) For food (milk and meat) (B) Source of income for other daily needs. (C) Cultural tradition (Maasai should own cattle) (D) Land conditions suitable for livestock rearing (E) For marriage ceremonies (to pay for brides) (F) As a form of wealth, security/safety net (G) For circumcision ceremonies (food, gifts)

For the most part, the views of focus group participants on the role of livestock corroborated those of key informants. Like key informants, participants in focus groups selected food and source of income as the most important reasons for owning livestock. Their ranking also indicated a strong perception that livestock rearing provides employment opportunities in arid and semi-arid environments where other land uses such as agriculture would not be viable. Participants in the focus group meetings stressed that local people are key stakeholders and custodians of wildlife. They emphasized the distinction between the pastoral culture of the Maasai and neighboring cultures that practice cultivation and traditionally hunted game.

It was clear from the discussions that although the Maasai are beginning to venture into small scale agriculture, their traditions still regard the opening up of soil for cultivation as sacrilege. They perceive pastoralism as a more reliable source of income than farming. One elderly man in the second focus group meeting said:

> The Maasai are only interested in grass for their cattle, just grass. We are not cultivators like our Kamba and Taveta neighbors. Cultivation diminishes grass and makes the land look empty when trees are cut. Those who cultivate harvest only once or twice a year but the Maasai have animals throughout the year and this provides us with a regular source of income from sales. We are surprised that when Maasai herders are caught grazing in the national parks, they are made to pay fines like someone who has killed wildlife. [December 9, 2015].

d) *What information on livestock grazing do you want to share with KWS officials?*

Participants were then asked to mention the issues they would like to share with KWS with regard to the issue of grazing both in the ranches and national parks. I outlined to each group some of the reasons KWS does not allow livestock grazing in the national parks. Some of the reasons I mentioned included: competition for grass and browse between wildlife and livestock, that livestock is a cause of park degradation, and that herders have sometimes colluded with elephant poachers (Table 6).

Participants in focus groups acknowledged the damage a large number of livestock can have on local vegetation and soils. There was general agreement in all the meetings that cattle have contributed to degradation in some parts of group ranches and the TWNP. But most participants expressed the view that the majority of local Maasai own livestock only for subsistence and have grazed responsibly. Participants blamed "immigrant livestock" for the influx of livestock in TWNP. They alleged that livestock from other parts of the country are brought to Tsavo with the full knowledge and cooperation of government officials.

Table 6: Contrasting Maasai and KWS views about livestock grazing in Tsavo

Impacts of grazing	Maasai	KWS officials
Competition for resources	Our animals graze without depleting forage for wild animals.	Parks are for wild animals. Livestock reduces pasture available for wildlife.
Woody plants	Eliminates invasive species that compete with native grass species.	Livestock tramples on grass and woody plants and can make land bare.
Fires	Reduces fire occurrence by reducing fuel loads.	During the dry season, herders lights fires in the park to promote new shoots for their animals.
Wildlife	Opens up the landscape, small herbivores can easily see their predators and vice versa.	Livestock compete with wild animals for grass.
Park security	Our herders look out for poachers and report suspicious activity to KWS officials.	Some Maasai herders are used as local guides by poachers who kill elephants for ivory in parks.
Disease interaction	We inoculate our livestock to reduce disease attacks.	Livestock can transmit diseases such as east cost fever to wildlife.

The Maasai explained that TaitaTaveta County where most of TWNP lie was declared a livestock disease free zone. This has encouraged livestock owners from arid northern parts of Kenya, especially the Somali, to bring their animals to community ranches within TaitaTaveta County. When grazing pastures diminishes in the ranches that neighbor the parks in Tsavo, the "immigrant livestock" is grazed illegally in national parks. Attempts by the Kenya Wildlife Service to drive out domestic animals from national parks are sometimes frustrated by local and national politics. Some participants alleged that senior government officials with high level political connections owned some of the "immigrant livestock."

Participants conceded that Maasai herders were responsible for some of the dry season fires that occurs in parts of Chyulu Hills which often spread into CHNP. They however, suggested that fires were necessary for killing ticks and other disease-causing pests. They added that fires promoted faster grass regeneration and ensured palatable grass for livestock and wildlife. When asked about the possible threat of disease transmission from livestock to wildlife, some informants reported that the Maasai inoculate their animals against infectious diseases. They reported that cows are regularly dipped in acaricides to control ticks. Livestock grazing was also reported to reduce invasive species in the landscape and also prevent encroachment of bush.

During the meetings, there were disagreements among participants in focus group meetings on issues of grazing and access to local resources. Some participants felt that the Maasai do not have to graze in the parks if they had a good plan to utilize pasture in the group ranches. This group of participants seemed to blame group ranch management committees for the mismanagement of pasture in the group ranches. They argued that local disagreements and inequality in livestock ownership were the causes of overgrazing and unequal access to pasture in the ranches. They stated that local wealthy livestock owners kept large herds of livestock and therefore took more than their fair share of group ranch resources. Such sentiments among "poorer" livestock owners have motivated calls for group ranch subdivision. One youthful Maasai said:

> If we utilize our pasture well in the ranches, we do not have to go to the park. But the leadership of the ranches has failed to come up with a good grazing management plan that ensures that pasture does not get depleted. Those who own big herds take all the grass. I support calls to subdivide the group ranches because we don't get any benefit from them. If the land is subdivided and I get my share, I will lease it to wealthy livestock owners who need it to graze their animals and I will make some income. Those who own many cattle such as 300 heads, are the only ones who benefit from group ranches.[December 13, 2015].

Participants also pointed out that TWNP and CHNP block traditional and historic routes of trade and transportation. Although a right of way has been granted through TWNP by KWS, participants said the route is not convenient for most local people. It was also revealed in the focus group meetings that despite a right of way across CHNP having been granted to the Maasai to take their livestock to markets in Kibwezi area by a former district commissioner, sometimes the Maasai are refused permission to take their animals through the park by KWS officials.

Focus group discussions also revealed that the relationship between local people and the KWS in relation to grazing is not always confrontational. Some participants explained that, at times there is "cooperation" between KWS rangers and local Maasai, where herders are allowed to graze in the park after giving "gifts" to KWS rangers. Most participants were hesitant to admit that such gifts offered to KWS rangers were a form of bribery. They insisted that park officials are their neighbors and as good neighbors they were expected to show mutual support and fellowship with the Maasai. Participants also reported that the majority of herders who take their animals in the park escape arrest from KWS rangers by taking vantage positions where they spot rangers from a distance and hide in the bush. It was also reported that young school-age boys are sent out to graze cattle in the park because KWS rangers are hesitant to arrest minors. And in any case, if the minors get arrested by KWS rangers, local police stations lack special facilities to handle underage offenders and they end up being released at the police station.

e) *How will an ACM plan with KWS resolve conflicts and promote elephant conservation?*

Participants were asked about the kind of ACM plan they would like to have with KWS that resolves grazing conflicts as a strategy for promoting elephant conservation. The issue of elephant poaching was mentioned by a majority of participants during the focus group meetings. Most participants underscored the role that the Maasai have played in protecting elephants in the ranches. They blamed elephant poaching on non-Maasai immigrants, especially from Tanzania, who recruit very poor Maasai (*dorobo*) as accomplices in poaching in ranches and parks. Participants also insisted that elephant poaching is more common in the parks than in Maasai group ranches, and attributed this to their vigilance in the group ranches. There was unanimous agreement in all focus group meetings that community projects have boosted local people's support for elephant conservation. Members of Mbirikani and Kuku group ranches have collaborated with investors who have set up luxury tented cottages and suites in their ranches. Part of the tourism revenue generated from these facilities directly supports community projects. One of the successful projects is the game scout's project whereby local people are recruited to provide security for wildlife. Such benefits from wildlife have enhanced local support for conservation. One participant said:

> The Maasai are helping the government to protect elephants. The eyes of KWS rangers cannot be everywhere because this area is vast and they are few, but we are many and we see more things than them. We have enjoyed some benefits of conservation, we now have schools and hospitals in this area which were built using money from wildlife tourism. We would like KWS to engage us more in protecting elephants.[January 3, 2016].

Participants insisted that their ranches are also wet season wildlife dispersal corridors and that elephants need the ranches for pasture and water. They pointed out that the survival of elephants will depend on the willingness of the Maasai to tolerate elephants in their villages. Some participants said that KWS should be mindful of the losses local people incur when predators kill their livestock or when elephants damage crops. The majority of participants felt that an adaptive co-management plan with KWS should recognize the role local people play in wildlife conservation. One participant said:

> We have been very active in protecting wildlife especially elephants and lions and we want to collaborate with KWS. They should listen to us when we tell them that livestock and wildlife can coexist. Our collaboration will work if they allow us some areas to graze our livestock.[December 28, 2015].

Participants suggested that in order to reduce grazing conflicts between them and KWS several steps were necessary. They preferred adaptive steps that are sensitive to their grazing concerns. Local participants unanimously agreed on seven steps (Figure 3) that they thought would support an ACM plan with the KWS. The seven steps in Figure 3, are in the context of the ACM approach, experiments that will be adjusted to new realities in future.

1. KWS and other government agencies to ensure that no 'immigrant livestock' is allowed in the Tsavo area.
2. Residents of the study area who own large numbers of livestock to voluntarily reduce their herds.
3. KWS to zone parts of TWNP and CHNP that have low tourism potential and designate these areas for livestock grazing during the dry season.
4. KWS and group ranch officials to establish joint grazing committees in each ranch comprising of KWS officials and local elders.
5. Introduce a grazing fee per head of cattle grazing in the park to be paid to KWS. This grazing fee to be used for catering administrative costs of grazing committees such as paying allowances to committee members.
6. KWS to develop training programs for local people to build capacity for participation in grazing committees.
7. Hold regular meetings between KWS officials and the Maasai.

Figure 3: Steps to an Adaptive Collaborative Management plan between the Maasai and the KWS as agreed by focus group participants

If the steps are implemented, new experiences will arise that might require new decisions or steps. During the discussions, participants agreed that the steps are not cast in stone; they will need continual feedback and evaluation. For instance, getting rid of "immigrant livestock" in Tsavo might encourage local people to increase their livestock herds. This might lead to the unintended consequence of more human-elephant conflicts. The steps outlined are therefore just the beginning of a learning process; all the feedback generated during their implementation will be used to improve future actions. The steps create new institutions; joint grazing management committees comprising of KWS and group ranch officials. This is an important adaptive tool for monitoring changes, proposing new actions and solving disputes that may arise.

Unlike the current practice where KWS uses its legal powers to enforce rules with regard to grazing, with little regard to the views of the Maasai, the ACM plan depends on the good will of the Maasai. In the spirit of ACM, the steps will be continuously validated and revalidated by the Maasai and KWS in order to produce the best outcomes acceptable to both parties. This will require negotiation and constant engagement between the Maasai and KWS. These steps towards an ACM plan are more likely to generate better outcomes than current practices which are hampered by confrontational power relations between KWS and the Maasai.

Village representatives were optimistic that adaptive plans with KWS would promote cooperation in elephant conservation. They also pointed out that such plans should only involve registered members of the three group ranches who are local residents. Participants were confident that an adaptive plan that focuses on livestock grazing would help solve the problem of "immigrant" livestock since local communities would ensure that livestock from other parts of the country were not allowed in the parks.

However, local views about co-management with KWS varied across villages and group ranches and among individuals. In Mbirikani and Kuku group ranches where there are active conservation programs driven by hotel and lodge operators, village representatives were more familiar with co-management ideas due to community based conservation programs in the area spearheaded by powerful conservation based non-governmental organizations such as the Big Life Foundation. Village representatives from the Rombo group ranch, where such programs were not active, seemed skeptical about whether KWS would agree to discuss grazing issues with the Maasai.

f) Interview with KWS officials on an ACM plan with the Maasai

Three KWS officials working in TWNP and CHNP were interviewed separately. The officials were in agreement that the Maasai are efficient livestock producers and are good protectors of their land. Two out of the three officials interviewed supported the proposal that the Maasai can be allowed to graze in the national park during the dry season but also added that such a move might invite the incursion of livestock from other parts of Kenya. The officials were in agreement that an ACM plan with the Maasai would work best if the government first solved the problem of "immigrant livestock." One of the KWS officials added that, there was a provision in Kenya's wildlife law that allows local communities to graze in the park in drought conditions. Section 102, subsection 4 of The Wildlife Conservation and Management Act, 2013 states that: "The Cabinet Secretary shall make guidelines in consultation with the Service with respect to accessing national parks for

purposes of grazing and watering livestock in times of drought and other natural disasters."

KWS officials explained that this legal provision has not been implemented because the number of livestock that entered the park illegally already exceed the "carrying capacity" of the parks. Most of these livestock is "immigrant" and is not owned by the local people. "Even if the Cabinet Secretary gave such a directive, it would be difficult to enforce", one KWS official concluded. The comments by KWS officials point to the conflicting views between local people and state resource agents about grazing in Tsavo. Their comments also indicated the willingness for dialogue and information sharing between the two parties.

IV. Discussion

Past conservation and development policies affecting East African pastoral rangelands were imposed from above (Schroeder 1999). Very little or no effort was made to include the views of pastoralists in policy making and planning processes (Boyd *et al*. 1999; Lamprey 1983; Lindsay 1987). For the most part, policies implemented in pastoral rangelands resulted in the disruption of access to seasonal water and pasture resources. This disruption is the genesis of contemporary conflicts between local pastoralists and conservation authorities. Despite the overwhelming evidence that the root cause of these conflicts is failure by planners to acknowledge features that are inherent in pastoral societies, East African governments, development experts, and conservationists continue to blame pastoralists for being ignorant, primitive and too stubborn to change their ways of life.

Pastoralists have lived with wildlife in savannah landscapes of East Africa for several millennia. This mutual coexistence had ecological benefits for people, livestock and wildlife. National park regulations in East Africa have outlawed livestock grazing within park boundaries. However, wildlife, especially elephants, often stray out of parks, sometimes posing a threat to livestock, crops and human life. As a result, pastoralists have perceived elephants as having a political advantage over humans, and have sometimes killed them in retaliation when elephants kill people or damage property (Norton-Griffiths 2000).

The narratives of the Maasai of Tsavo about the role of livestock grazing in their landscape resonate with views of other pastoralists across the world who give their own subsistence top priority. Just like other pastoralist in East Africa (Halderman 2013; McCabe 1990), the Maasai of Tsavo believe that wildlife and livestock can share grazing resources and co-exist with minimal conflict. Narratives from participants in this study suggest that cattle and elephants are at the heart of Maasai culture. Among the Maasai, livestock is historically a source of nourishment and currently a source of income. Local narratives indicate that traditionally, elephants were valued for customary reasons and were never used for economic reasons. Killing of elephants was a taboo in Maasai culture. Neighboring tribes who hunted and consumed elephant meat were seen as dirty and "uncivilized." This research supports other findings where pastoralists tolerate wildlife in their lands as a traditional cultural obligation. A good example is research done among the Samburu pastoralists of Kenya (Kuriyan 2002). It was clear during this research that although KWS officials emphasized the importance of elephants for tourism, local narratives were more focused on the role of elephants in cultural and naturalheritage.

The study also revealed differences in perceptions of corruption between KWS officials and the Maasai. Senior KWS officials interviewed in this study stated categorically that it is a malpractice for any KWS officer to accept gifts in exchange for allowing livestock access in the park. However, the Maasai do not perceive KWS rangers who accept their "gifts" in exchange for livestock access to the park as corrupt. Despite their awareness of park regulations, the Maasai perceive such rangers as good neighbors who embrace the need for cooperation and mutual aid. This finding about "mutuality" in peasant societies echoes other political ecology research such as Neumann's work around Arusha National Park in Tanzania (Neumann1998). Paying small bribes to rangers by the Maasai can be understood within theories of "village moral economy" and "every day forms of peasant resistance"elaborated by Scott (Scott 1976; 1985). The Maasai resist park policies that threaten their livelihoods by grazing illegally in the parks.

a) Balancing KWS and Maasai interests through Adaptive Collaborative Management

The shift from equilibrium to non-equilibrium views of social ecological systems provided support for management approaches that embrace more adaptive and collaborative forms of natural resource management (Berkes and Folke 1998; Hollin*get al*. 2002; Mclain and Lee 1996; Sluyter 2002). One such approach that has emerged in natural resource management is Adaptive Collaborative Management (ACM). Although there is no single universally accepted definition of ACM, it emerged from two concepts: co-management and adaptive management. Co-management emphasizes that stakeholders who have a claim to a certain natural resource should share rights and responsibilities of managing such a resource (Colfer 2005). ACM also recognizes that human knowledge is imperfect and incomplete because the world keep changing and presenting new surprises. Some of the recent changes affecting natural resource management include; rapidly changing human population, land use and climatic patterns, new

resource conservation laws, etc. Therefore, in ACM, policy choices are treated as experiments which can succeed or fail. When policies fail, policy makers learn from past experiences and adjust management actions in a continual cycle of action, learning and adjusting policies (Armitage*et al*. 2008b). ACM is now widely recognized as a tool that can be applied to solve complex natural resource conservation problems.

ACM supports the shift from the "fences and fines" approach to people-focused approaches in natural resource management (Holmes 2003). It emphasizes not just the co-operation of various stakeholders but also their contribution of knowledge (Fisher 2001). Focus group discussions held in this study show that the Maasai are willing to share their knowledge about elephants and livestock grazing with the KWS. It is clear that the Maasai would support opportunities to work with the KWS to resolve grazing conflicts through an agreed ACM plan. The seven adaptive steps suggested by participants in focus group meetings (Box 1) represent important first steps towards an adaptive collaborative plan. However, since no human activities are allowed in national parks, according to current national park regulations in Kenya, the success of such a collaborative plan will require changes in policy. These policy changes should embrace local participation and integration of local knowledge in conservation planning. The new policies should be a break away from the prevailing "command and control" approaches that marginalize, ignore, and devalue Maasai knowledge and culture.

Maasai views on livestock and elephants support the "polycentric" governance, and "citizen science" approaches (Dickinson *et al*. 2010; Ostrom 2005; 2010), whereby governments at multiple scales interact with community organizations so that management decisions are made at local places by a diversity of actors. In some of the success stories where the polycentric approach has been applied in resource management, local groups have been given the independence to make and enforce rules within a specified geographical area (Acheson 2003; Singleton 1998). In these cases, community groups have worked together with governments to devise rules to manage natural resources on which they rely for livelihood. Such co-management systems enhance localized control over resources and may reduce resource conflicts. Our research shows that the Maasai prefer an adaptive co-management plan with KWS that supports the co-managementof wildlife resources in their landscape.

V. Conclusion

The goal of this study was to gain local perspectives on the role of livestock grazing in Maasai villages adjacent to CHNP and TWNP in Kenya and validate those perspectives towards an adaptive collaborative management plan between the Maasai and KWS that enhances the protection of elephants. Using a participatory learning approach, I investigated local knowledge on livestock grazing and sought to understand how this knowledge relates to the conservation of elephants. I also explored how resolving grazing conflicts between the Maasai and KWS can be an avenue for ensuring the future survival of elephant populations in Tsavo. Results shows that local people regard livestock as a critical component of their pastoral livelihoods,their views differs from official perceptions that portray livestock as a threat to key wild species, especially elephants.

According to the narratives of Maasai participants in this study, shared grazing between livestock and wildlife is mutually beneficial and also supports grassland ecosystems. Livestock grazing prevents the spread of invasive species and also maintains savannah grasslands by curbing the encroachment of bush. Local knowledge of the Maasai dictatesthat the ability to move to other lands to exploit pastures and water resources is a key survival mechanism for livestock in times of droughts. Currently, most of the traditional grazing frontiers for the Maasai fall in national parks,where cattle grazing is officially prohibited. Participants in this study expressed the need to graze in national parks during times of severe droughts in order to protect their livelihoods. This might require the adjustment of national park policies. Although the extent of landscape transformations in Tsavo will not allow for a return to traditional grazing patterns, there is need for grazing plans in the region to build on traditional grazing practices.

This study validates Maasai knowledge and argues for its inclusion in adaptive co-management plans with the KWS. Clearly, the Maasai residents of Tsavo would like greater participation in conservation decision making. Successful biodiversity conservation in East Africa will depend on cooperation between state conservation officials, local farmers, and pastoralists to protect wild species. This chapter asserts that negotiations between the Maasai and KWS officials in Tsavo, Kenya to jointly forge new conservation plans will safeguard local livelihoods and promote the survival of elephants. As Daniel Wildcat argues in his book *Saving the Planet with Indigenous Knowledge,* indigenous traditions and world views must be acknowledged for us to be successful in saving the last great species and places on earth (Wildcat 2009). Resolving grazing conflicts between the Maasai of Tsavo and the KWS will promote the long term conservation of elephants in the Tsavoregion.

References Références Referencias

1. Acheson, J. M. 2003. *Capturing the commons: Devising institutions to manage the Maine lobster industry*. Hanover, NH: University Press of New England.
2. Armitage, D., R. Plummer, F. Berkes, R. Arthur, A. Charles, A., Davidson-Hunt, I., Diduck., N. Doubleday, D. Johnson, M. Marschke, P. McConney, E. Pinkerton, and E. Wollenberg. 2008b. Adaptive co-management for social-ecological complexity.*Frontiers in Ecology and Environment* 7 (2): 95-102.
3. Augustine, D.J. 2003. Long term, livestock mediated redistribution of nitrogen and phosphorous in an East African savanna. *Journal of Applied Ecology* 40 (1):137-149.
4. Bekure, S. &P.N. de Leeuw, 1991. The potential for improving the livestock production and welfare of the pastoral Maasai. In *Maasai Herding: An analysis of the livestock production system of Maasai pastoralists in eastern Kajiado district, Kenya,* ed. S. Bekure, P.N. de leeuw, B.E. Grandin& P.J.H Neate.141-152.International Livestock Center for Africa (ILCA).
5. Berkes, F. & C. Folke. 1998. Linking social and ecological systems for resilience and sustainability. In *Linking social and ecological systems: Management practices and social mechanisms for building resilience,* ed. F. Berkes, and C. Folke, 1-26. United Kingdom: Cambridge University Press.
6. Boyd, C., R. Blench, D. Bourn, L. Drake, and P. Stevenson. 1999. Reconciling interests among wildlife, livestock and people in East Africa: A sustainable livelihoods approach. *Natural Resource Perspectives*45, June 1999.
7. Brockington, D. 2005. The contingency of community conservation.In *Rural resources and local livelihoods in Africa,* ed. K. Homewood, 100-120. Oxford: James Currey Ltd:
8. Campbell, D.J., D.P. Lusch, T.S. Smucker, and E.E. Wangui, 2003.*Root causes of land use change in the Loitoktok area, Kajiado District, Kenya*. Land use change impacts and dynamics (LUCID) Working Paper 19). Nairobi, Kenya: International Livestock Research Institute.
9. Colfer, C.J.P. 2005.*The complex forest: Communities, uncertainty and adaptive collaborative management*. Washington: Resources for the Future Press.
10. Dickinson, J.L, B. Zuckerberg, and D.N. Bonter. 2010. Citizen science as an ecological research tool: Challenges and benefits. *Annual Review of Ecology, Evolution, and Systematics* 41:149-172.
11. Dublin, H.T. 1995. Vegetation dynamics in the Serengeti-Mara ecosystem: The role of elephants, fire, and other factors. In *Serengeti II: Dynamics, management and conservation of an ecosystem,* ed. A.R. Sinclair and P. Arcese, 71-90. Chicago: University of Chicago Press.
12. Ellis, J. and D. Swift.1988. Stability of African pastoral ecosystems: Alternate paradigms and implications for development. *Journal of Range Management* 41 (6):450-459.
13. Fisher, R.J. 2001.Experiences, challenges, and prospects for collaborative management of protected areas: An international perspective. In *Biological diversity: Balancing interests through adaptive collaborative management*, ed. E. Buck., C.C. Geisler, J. Schelhas and E. Wollenberg, 81-94. London: CRC Press.
14. Halderman, J.M. 2013.*Pastoralism in the horn of Africa: Classic and current issues*.University of California, Berkeley: Center for African Studies.
15. Harding, G. 1968. The tragedy of the commons.*Science* 162:1243-1248.
16. Herskovits, M.J. 1926. The cattle complex in East Africa.*American Anthropologist* 28 (1): 230-272.
17. Holling, C.S., L.H. Gunderson and D. Ludwig.2002. In a quest of adaptive change. In *Panarchy: Understanding transformations in human and natural systems*, ed. C.S. Holling, and L.H. Gunderson, 3-24. Washington, DC: Island Press.
18. Holmes, C.M. 2003. The influence of protected area outreach on conservation attitudes and resource use patterns.A case study from Western Tanzania.*Oryx* 37 (3): 305-315.
19. Homewood, K., and W.A. Rogers.1991. *Maasailand Ecology: Pastoralist development and wildlife conservation in Ngorongoro, Tanzania*. Cambridge: Cambridge University Press.
20. Johnson, R. and J. Tothill.1985. Definitions and broad geographic outlines of savanna lands.In *Ecology and management of the world savannahs*, ed. J. Tothill and J. Motts, 1-13.Canberra: Australian Academy of Science.
21. Kuriyan, R. 2002. Linking local perception of elephants and conservation: Samburu pastoralists in Northern Kenya.*Society and Natural Resources* 15: 949-957
22. KWS (Kenya Wildlife Service). 2014. *Annual report 2014*. Nairobi, Kenya: Kenya Wildlife Service.
23. Lamprey, H. 1983. Pastoralism yesterday and today: The overgrazing problem. In *Tropical savannas*: *Ecosystems of the world*, ed. F. Bourliere, 643-666. Amsterdam. Elsevier Scientific Publishing Company.
24. Laris, P. 2006. Managing a burning mosaic: A landscape scale human ecological model of savanna fires in Mali. In *Savannas and dry forests: Linking people with nature*, ed. M. Jayalaxsmi, and A. Berardi, 155-186. England: Ashgate Publishing Company.

25. Lindsay, W.K. 1987. Integrating parks and pastoralists: Some lessons from Amboseli. In *conservation in Africa: People, policies and practice,* ed. D. Anderson and R. Groove, 149-168. New York: Cambridge University Press.
26. Little, P.D. 1996. Pastoralism, biodiversity and the shaping of savannah landscapes in East Africa. Africa: *Journal of the International Africa Institute* 66 (1): 37-51.
27. Lore, M. and Mulder, M. 1999. Are East African pastoralist's truly conservationists? *Current Anthropology* 40 (5): 621-652.
28. McCabe, J.T. 1990. Turkana pastoralism: A case against the tragedy of the commons. *Human Ecology, 18* (1): 81-103.
29. McLain, R.J. and Lee, R.G. 1996. Adaptive management: Promises and pitfalls. *Environmental Management* 20(4): 437-448.
30. Ndi, F.A. and S. Batterbury. 2017. Land grabbing and the axis of political conflicts: Insights from Southwest Cameroon. *Africa Spectrum* 1: (2017): 33-63.
31. Neumann, R. P. 1992. 'The political ecology of wildlife conservation in the Mount Meru area, North East Tanzania'.*Land Degradation and Rehabilitation* 3 (2):85-98.
32. ___1997. Primitive ideas: Protected area buffer zones and the politics of land in Africa. *Development and Change* 28 (3): 559-582.
33. ___1998. *Imposing wilderness: Struggles over livelihood and nature preservation in Africa.* Los Angeles: University of California Press, Ltd.
34. Nkedianye, D., J. de Leeuw, J.O. Ogutu, M.Y. Said, T.L. Saidimu, S.C. Kifugo, D.S. Kaelo, and R.S. Reid. 2011. Mobility and livestock mortality in communally used pastoral areas: The impact of the 2005-2006 drought on livestock mortality in Maasailand. *Pastoralism: Research, Policy and Practice* 1:1-17.
35. Norton-Griffiths, M. 2000. Wildlife losses in Kenya: An analysis of conservation policy. *Natural Resources Modelling* 13 (1): 1-16.
36. Ntiati, P. 2002. *Group ranch subdivision in Loitoktok Division of Kajiado District, Kenya*.(Land use change impacts and dynamics (LUCID), Working Paper 7). Nairobi, Kenya: International Livestock Research Institute.
37. Oketch, R.N. 2010. Wildlife-community conflicts in conservation areas in Kenya. *African Journal of Conflict Resolution* 10 (2), 65-80.
38. Olsson, P. and C. Folke.2001. Local ecological knowledge and institutional dynamics for ecosystem management: A study of Lake Racken watershed, Sweden. *Ecosystems* 4: 85-104.
39. Ostrom, E. 1990. *Governing the commons. The evolution of institutions for collective action*. Cambridge: Cambridge University Press. *Understanding institutional diversity*. Princeton and Oxford. Princeton University Press.
40. __.Polycentric systems for coping with collective action and global environmental change.*Global Environmental Change* 20: 550-557.
41. Pimbert, M.P. and Pretty, J.N. 1997. Parks, people and professionals: Putting 'participation' into protected area management. In *Social change and conservation*, ed. K.B. Ghimire and M.P. Pimbert, 297-331. London: Earthscan.
42. Reid, R.S. 2012. *Savannas of our birth: People, wildlife, and change in East Africa*. Berkeley and Los Angeles: University of California Press. .
43. Republic of Kenya (R.O.K). 2013. *Kajiado County Integrated Development Plan, 2013-2017.* Nairobi: Kenya. Government Printers.
44. Roquest, K.G., T.G. O'Connor, and A.R. Watkinson.2001. Dynamics of shrub encroachment in an African savanna: Relative influences of fire, herbivory, rainfall and density dependence. *Journal of Applied Ecology,* 38 (2), 268-280.
45. Schroeder, R. A. 1999. Geographies of environmental intervention in Africa. *Progress in Human Geography,* 23 (3), 359-378.
46. Scott, J.C. 1976. *The moral economy of the peasant: Rebellion and subsistence in Southeast Asia.* New Haven and London: Yale University Press.
47. __. *Weapons of the weak: Everyday forms of peasant resistance*. New Haven: Yale University.
48. Sheuyange, A., G. Oba, and R.G. Weladji.2005. Effects of anthropogenic fire history on savanna vegetation in Northeastern Namibia. *Journal of Environmental Management* 75: 189-198.
49. Singleton, S. 1998. *Constructing cooperation: The evolution of institutions of co-management in Pacific Northwest salmon fisheries*. Ann Arbor. University of Michigan Press.
50. Sluyter, A. 2002.*Colonialism and landscape: Postcolonial theory and applications*. Lanham, MD: Rowman and Littlefield.
51. Walter, H. 1971. *Ecology of tropical and sub-tropical vegetation*.Edinburg: Oliver and Boyd.
52. Ward. D. 2005. Do we understand the causes of bush encroachment in African savannas? *AfricaJournal of Range and Forage Science* 22(2): 101-105.
53. Waweru, F.K. and W.L. Oleleboo. 2013. Human-wildlife conflicts: The case of livestock grazing inside Tsavo West National Park, Kenya. *Research on the Humanities and Social Sciences* 3 (19): 60-67.
54. Western, D. 1994. Ecosystem conservation and rural development: The case of Amboseli. In *Natural connections: Perspectives in community-based conservation,* ed. D. Western, R.M. Wright, and S. Strum, 15-52. Washington, DC: Island Press.

55. Wildcat, D.R. 2009.*Red Alert: Saving the planet with indigenous knowledge*. Golden, Colorado: Fulcrum Publishing.

Archival sources

56. Kenya National Archives. KL/1/32.*Development organizational policy, Tsavo National Park*.
57. Kenya National Archives. KL/1/54.*Tsavo National Park.*

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Assessment of Spatial Variability of Physico Chemical Properties of Soil at Crop, Soil and Pest Management Research Farm, Futa

By Obafemi Olutola OLUBANJO & Samuel Oluwamayowa AYOOLA
Federal University of Technology Akure

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Keywords: *spatial variability, soil physico-chemical property, GPS procedures, sampling point, land use management practices, fertility assessment.*

GJSFR-D Classification: *FOR Code: 050399, 070399*

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Assessment of Spatial Variability of Physico Chemical Properties of Soil at Crop, Soil and Pest Management Research Farm, Futa

Obafemi Olutola OLUBANJO [α] & Samuel Oluwamayowa AYOOLA [σ]

Abstract- Soil is an important natural resource for growing plants and the suitability of soil for crop production is based on the quality of the soil's physical, chemical and biological properties. The objectives of the study were to determine the soil physical and chemical properties and characterize the spatial variability of soil physico-chemical properties across the study area. The study was conducted at Crop, Soil and Pest Management Research Farm, Futa. Soil samples were collected from six sampling depths between 0-60 cm at an interval of 10 cm at different 20 points across the field while coordinates of the soil sampling points were determined using Global Positioning System (GPS) procedures. The test for variance was carried out on physical properties of %sand, %silt, %clay, bulk density (g/cm^3), %porosity, %water holding capacity (WHC) and soil hydraulic conductivity and chemical properties on pH, organic matter content (%), total nitrogen (%), available phosphorus (ppm), calcium, magnesium, sodium and potassium (cmol/kg), and effective cation exchange capacity (cmol/kg). The laboratory analysis (soil textural analysis) revealed that the soil type at the site was were predominantly Sandy Clay Loam. Gravimetric soil moisture content and the water holding capacity (WHC) in all the 20 sampling spots at the topsoil has a mean value of 9.13% ± 1.90 and 52.43%±2.45 respectively. The minimum and maximum hydraulic conductivity (K) value at the distribution shows a moderately skewed distribution of the K data and the distribution is positively skewed. The mean pH value of the soil in the study site was found to be slightly acidic and the soils were low in soil OM. The CEC, Mg^{2+}, OC, TEB and TN indicated significant difference for soil chemical properties. The physical properties and chemical properties as at the time of the study were found to be optimal for crop production, fertility assessment and land use management practices for crop productions and drip irrigation is suitable for the study area.

Keywords: spatial variability, soil physico-chemical property, GPS procedures, sampling point, land use management practices, fertility assessment.

I. Introduction

Soil is an important natural resource for growing plants. The suitability of soil for crop production is based on the quality of the soil's physical, chemical and biological properties. Soil therefore, is a dynamic natural body having properties derived from the combined effects of climate and biotic activities, as modified by topography, acting on parent materials over time. (De Gomez, 2015). One of the naturally occurring processes that affect soil properties and subsequent crop production is the pattern of water movement along the slope. The geometry of slope such as slope angle, length and curvature influence runoff, drainage, and soil erosion causing a significant difference in soil physico-chemical properties (Musa and Gisilanbe, 2017).

There are several human activities that can alter the soil properties of ecosystems such as, agricultural practices, urbanization and mining. Due to the nature (aridity) and climate of Nigeria the most common practice that has an adverse effect on the soil or ecosystems on the larger scale is mining (Linus, 2010; Burke, 2014)

Variability in soil properties is a direct result of the five soil forming factors: climate, organisms, relief, parent materials and time. Of the five soil forming factors, relief (topography) can be the most readily assessed factor as the changes in field topography influence the distribution of soil properties and crop productivity. (Mzuku *et al*., 2005: Akbas, 2014).

A better knowledge of the spatial variability of soil properties is important for refining agricultural management practices and for improving sustainable land use as reported by Akbas (2014); Omotade and Alatise (2017). Also, understanding the role of several soil properties together, and their interactions, may help to explain the cause of variation in crop productivity as defined by the management practices (Rahal, 2015). Spatial variability is primarily attributable to the differences in the soil physical and chemical properties while temporal variability may be as a result of farming systems or moisture content differences (Koech *et al*., 2010; Omotade and Alatise, 2017). Temporal variability is as a result of infiltration variability that causes non uniformity in soil moisture content. Water is essential to plants and to complement natural sources, irrigation is introduced to satisfy plant moisture requirements. Irrigation can ensure adequate and reliable supply of water which increases yields of most crops by 100% to 400%. For any given irrigation interval, optimal irrigation required less (48-63%) water than full irrigation. This also reduced both the deep percolation and runoff losses and caused a 31-43% increase in the application efficiency (Omotade and Alatise, 2017).

Author α σ: Department of Agricultural and Environmental Engineering, Federal University of Technology, Akure, Nigeria.
e-mail: olubanjoobafemi@gmail.com

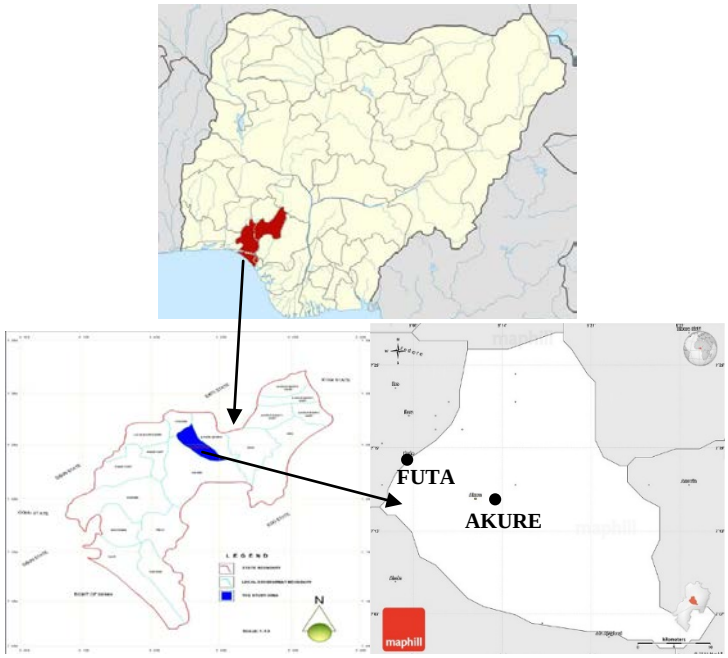
Soil spatial variability is an important determinant of efficiency of farm inputs and yield, (Rahal, 2015) as well as crop management and design and effectiveness of field research trials .These variations differed among soil properties, and may reflect the impacts of plant, soil fauna, precipitation, and management practices adopted in the area (Rahal, 2015). Consequently, soils can exhibit marked spatial variability at the macro-scale and micro-scale. High variability of soil properties might be related to variability of properties of flood sediments, and controlled by primarily the depositional environment where high energy systems deposit materials with high spatial variability (Rahal, 2015; Omotade and Alatise, 2017). These processes and causes create pattern of nested variability or heterogeneity, this means that, soil properties may display spatial/or temporal patterns only over certain distances and not others (Douaik, 2011; Rahal, 2015).

The characterization of the spatial variability of soil attributes is essential to achieve a better understanding of complex relations between soil properties and environmental factors (Goovaerts, 1998: Taiwo *et al*., 2016). Also, useful estimates of attributes at unsampled locations, leading to better recommendations for the application of water, plant nutrients, fertilizers or pesticides can be achieved from the modelling of spatial dependence between soil data (Goovaerts, 1998). The objectives of the study was to determine the soil physical and chemical properties and characterize the spatial variability of soil physico-chemical properties, determine the type of irrigation system and crop that is suitable for the study area.

II. Materials and Methods

a) Study Area

This study was conducted at the Crop, Soil and Pest Management Research Farm Land, Federal University of Technology Akure Ondo State, Nigeria. Akure is located on the latitude 7°13'N and longitude 5°13'E within the humid region of Nigeria and lies in the rain forest zone with a mean annual rainfall between 1300-1600mm and an average temperature of 27°C. The relative humidity ranges between 85 and 100% during the rainy season and less than 60% during the dry season period. The study was carried within a total marked size of 2476m^2 (Omotade and Alatise, 2017).



Source: Googlemap, 2018

Figure 1: Map of Nigeria Showing Ondo State, Akure and FUTA

b) Soil Sampling Techniques and Preparation

i. Soil sampling techniques

Random Soil samples was collected within the area within six sampling depths 0-10 cm, 10-20 cm, 20-30 cm, 30-40 cm, 40-50 cm and 50-60 cm of the soil using a soil auger at 20 different points covering the study site. A total of 20 sub-samples were taken at the depth of 0-10 cm using a garden shovel, away from the nearby plants in the open area. Plants affect physical and chemical soil properties through the alteration of infiltration and runoff (Esler and Cowling, 1993; Sanjib *et al*., 2016), therefore samples were taken away from them. These soil samples were obtained to determine the soil moisture content at different depths and collectively added together to determine the spatial variability of all other properties at different points within the study area i.e. (Point A to T= soil from depths (0-10 cm) + (10-20 cm) + (20-30 cm) (30-40 cm) + (40-50 cm) + (50-60 cm) accordingly). The sampling points were located on the site using Global Positioning

System (GPS) equipment. The highest elevation is 381m while lowest level is 365 m above sea level as shown in Figure 2 with spatial variability of soil attributes in different landscape positions which was determined using geo-statistics techniques (Omotade and Alatise, 2017).

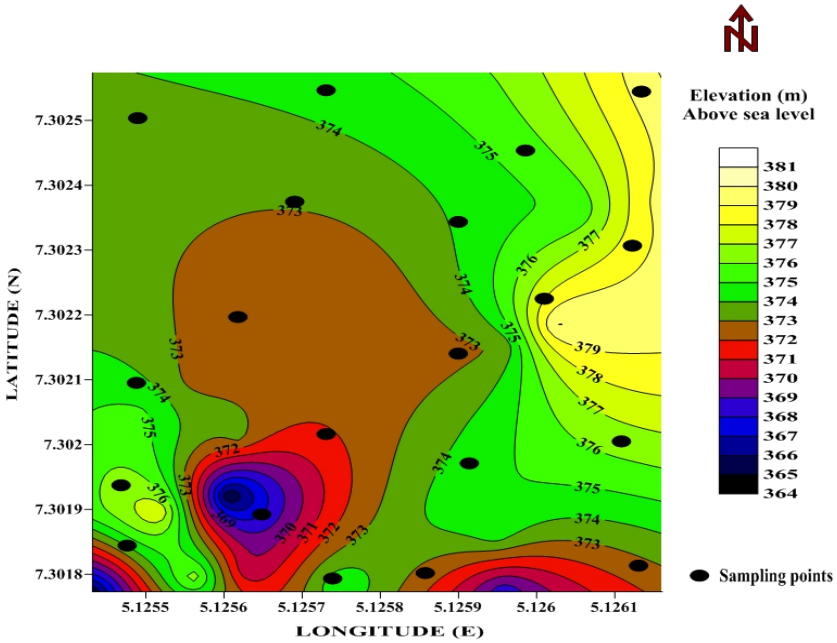


Figure 2: Map showing the elevation of the study area above the sea level

c) Soil Physical Properties

The particle- size distribution (soil texture) was determined by Bouyoucos hydrometer method (Gee and Bouder, 1986; Omotade and Alatise, 2017). The soil bulk density was determined using cylindrical metal core sampler method (Musa and Gisilanbe, 2016) by dividing the weight (W) of dry soil by the internal core volume (v) of the core sampler. Thedefaultvalueof2.65 Mg/m^3 is used as a rule of thumb based on the average bulk density of rock with no pore space to determine the total porosity (PD) (Fasinmirin and Olorunfemi, 2013; Taiwo *et al*., 2016). The total porosity in m^3m^{-3}, was estimated using the ratio between the BD and PD through the following equation (Fasinmirin and Olorunfemi, 2013). The soil moisture content was determined using gravimetric method (Omotade and Alatise, 2017). The Values of soil water holding capacity (SWSC) at the 0.00-0.60 m depth, expressed in percentage, were calculated by the expression (Taiwo *et al*., 2016).

d) Soil chemical properties

The pH of soil was measured on all the collected soil samples (120 soil samples) on saturated paste using digital electronic pH meter (Sanjib *et al*., 2017). The Walkley-Black method was used to determine the percentage organic matter in all samples of soil and post-mining waste materials (Sanjib, 2016; Omotade and Alatise, 2017). A modified Kjeldahl method was used to determine total nitrogen of soil samples (Sanjib, 2016; Omotade and Alatise, 2017). The content of Extractable macronutrients (Mg^{2+}, P and Ca^{2+}) and (K^+ and Na^+) in the 120 soil samples collected during field work was extracted at the analytical laboratory using neutral normal ammonia acetate and flame photometry (Sanjib *et al*., 2016). The available Phosphorus was determined by extraction method using spectrometer and Bray's P-1 reagent (Musa and Gisilanbe, 2017).

The obtained data was analysed using statistical analysis such as descriptive statistics; Minimum (Min), Maximum (Max), Mean, Standard deviation (SD), Coefficient of variance (CV) and Skewness using Microsoft Excel 16.00 (Microsoft Inc., USA) software package for windows (Omotade and Alatise, 2017) The relationship between the studied Soil properties were established using Pearson's correlation coefficient analysis. Significant difference were observed at $P>0.05$ (Sanjib *et al*., 2016)

All data corresponding to each grid point location were interpolated spatially using global positioning system (GPS) and selected data will be interpolated using SURFER software. The point XYZ data survey of the prescribed sample grids at the agricultural farm will be analysed for land scape positioning, according to the landform classification developed by Pennock *et al*. (1994).

III. Results and Discssion

a) Soil Physical Properties

i. *Soil texture*

The soil textural analysis was performed on the soil samples taken from the study area for depth 0-30 cm and the relationships were presented in the Figure 3. The laboratory analysis (soil textural analysis) revealed that the soil type at the site was were predominantly Sandy Clay Loam according to USDA soil textural classification (Soil Survey Staff, 1999). Sandy Clay Loam usually facilitates water infiltrability and nutrients retainability (Shukla and Lal, 2002; Omotade and Alatise, 2017). The descriptive statistics of particle size distribution of the site indicates that the soils generally have an average sand content of 45.80% ± 5.60, 46.50% ± 4.51, 46.90% ± 4.75 for depth 10 cm, 20 cm and 30 cm respectively as presented in Table 1.

Table 1: Descriptive statistics of particle size distribution of the experimental site

Variables/statistics	%Sand			%clay			%silt		
Depths, cm	10	20	30	10	20	30	10	20	30
Mean	45.80	46.50	46.90	37.80	36.10	35.80	16.40	17.40	17.30
StDev	5.60	4.51	4.75	6.56	5.93	5.35	2.11	2.26	1.49
CV	31.37	20.33	22.52	42.99	35.15	28.67	4.46	5.09	2.22
Kurtosis	-0.86	1.44	-0.45	-0.62	0.26	-0.40	-0.48	-1.46	-0.76
Skewness	-0.67	-1.51	-0.25	0.98	1.15	0.14	0.75	-0.07	0.70
Range	16.00	16.00	18.00	18.00	18.00	20.00	6.00	6.00	4.00
Min	36.80	36.80	36.80	31.20	31.20	27.20	14.00	14.00	16.00
Max	52.80	52.80	54.80	49.20	49.20	47.20	20.00	20.00	20.00
Count	20	20	20	20	20	20	20	20	20

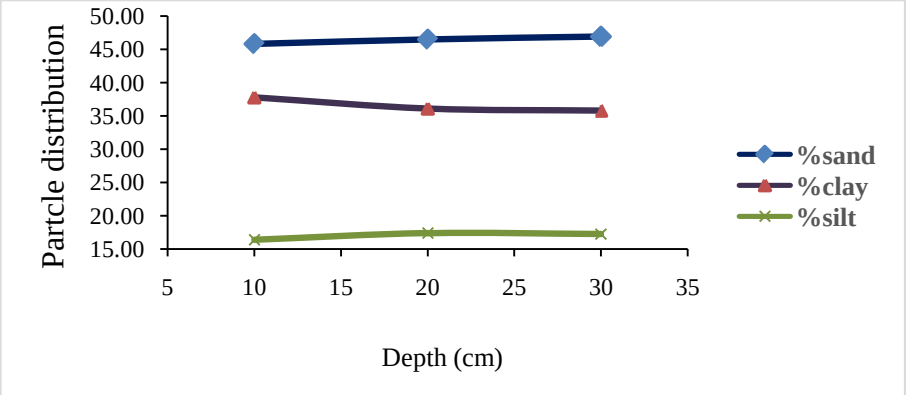


Figure 3: The textural classification of soil

ii. *Bulk density (BD) and Total porosity (TP) of experimental field*

Bulk density (BD) increased significantly with depth from about 1.28 Mg/ m^3 to 1.59 Mg/ m^3 in the top 10 cm depth to 1.61 Mg/m^3 in the 60 cm depth ($p \leq 0.001$) (Table2). As expected, mean Total Porosity, TP (0.46>0.45>0.44>0.43 m^3/ m^3) also significantly decreased with soil depth ($p \leq 0.001$) (Table 2). The general trend of increase in BD observed in the soil layers is in conformation with Vereecken *et al.* (1989), Adeyemo and Agele (2010) and Fasiminrin and Olorunfemi (2012). The increase down the soil profile is probably due to changes in soil texture, gravel content, and structure (Landsberg *et al*., 2003) but also because of biological activity on surface soils with high organic matter content which decreases across the soil profile (Fasinmirin and Olorunfemi, 2013 and Taiwo *et al*., 2016.). This is also expected because of the overburden weight of soil above the depth of measurement (Taiwo *et al*., 2016). Total porosity as expected showed inverse relationship to the bulk density of the experimental site (Figure 2). This observation agrees with the works of Vogelmann *et al*., (2010) Olorunfemi and Fasinmirin, 2012 and Taiwo *et al*., 2016). Meanwhile, values for the BD at the experimental field are similar to those reported by, Fasinmirin and Olorunfemi (2013) and Taiwo *et al*., (2016).

Table 2: Descriptive statistics of bulk density (BD), total porosity (PT),Soil Water Holding Capacity (SHWC) and Soil Hydraulic Conductivity (K) of the experimental field

Variables/statistics	BD, g/cm^3			TP, m^3/m^3			SHWC (%)			K(cm/hr)		
Depths, cm	*30*	*20*	*10*	*30*	*20*	*10*	*30*	*20*	*10*	*30*	*20*	*10*
Mean	1.468	1.425	1.425	44.614	46.219	46.219	52.734	53.745	52.430	0.00888	0.00925	0.00917
Median	1.490	1.410	1.435	43.773	46.791	45.838	53.097	53.606	52.577	0.00015	0.00014	0.00013
StDev	0.083	0.052	0.106	3.130	1.967	4.012	2.587	2.072	2.445	0.00875	0.00929	0.00916
CV	0.007	0.003	0.011	9.797	3.868	16.094	6.693	4.293	5.976	0.00069	0.00062	0.00058
Kurtosis	-1.155	-0.423	-1.395	-1.155	-0.423	-1.395	-0.395	-1.212	-0.892	0.65318	-0.29732	-0.34450
Skewness	-0.427	0.532	0.155	0.427	-0.532	-0.155	-0.806	0.182	-0.173	0.00236	0.00216	0.00210
Min	1.322	1.347	1.280	40.596	41.867	39.961	47.884	50.689	48.432	0.00795	0.00801	0.00808
Max	1.574	1.541	1.591	50.126	49.173	51.714	55.841	57.076	56.116	0.01031	0.01018	0.01018
Sum	29.354	28.504	28.504	892.290	924.374	924.374	1054.687	1074.910	1048.599	0.17753	0.18492	0.18339
Count	20	20	20	20	20	20	20	20	20	20	20	20

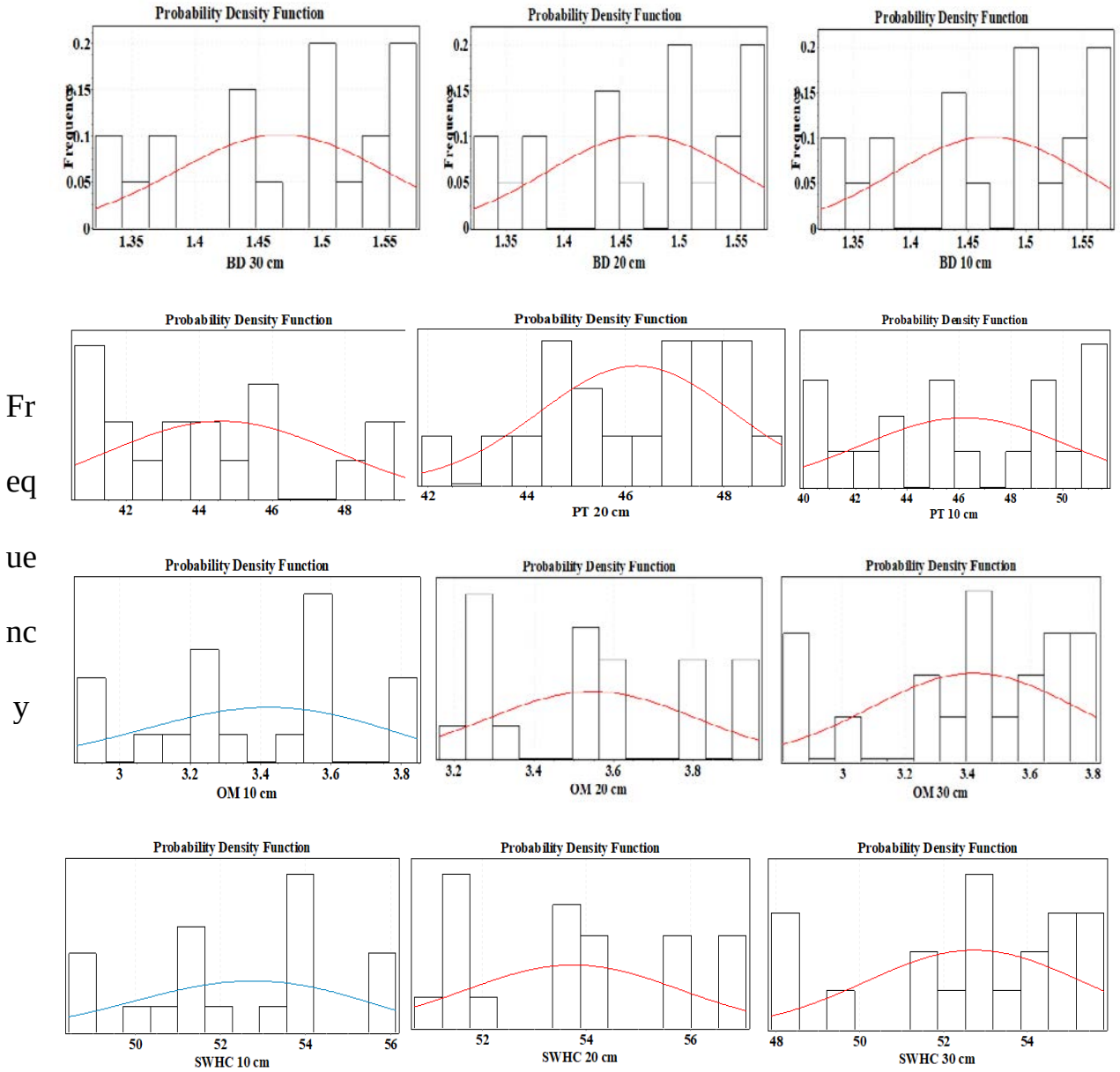


Figure 4: Histogram with normal curve of bulk density (g/cm^3), total porosity (m^3/m^3), soil water holding capacity (%) and soil organic matter (%) of the experimental field at 10, 20 and 30 cm depths respectively

iii. *Soil Moisture Content, Soil Water Holding Capacity (SWHC) and Soil Hydraulic Conductivity (K)*

The knowledge of these soil hydraulic properties and the soil water storage capacity processes leads to better predictions of both agricultural and environment impact. Soil hydraulic properties also define the relationship between soil moisture, hydraulic head and hydraulic conductivity, thus controlling how water moves through the soil. (Taiwo *et al*., 2016)

Gravimetric soil moisture content ranged from 5.33% to 14.52% in all the 20 sampling spots at the topsoil with a mean value of 9.13% ± 1.90 and coefficient of variation of 3.6. The water holding capacity (WHC) ranged from 48.43% to 56.12% for all the top soil layer in the 20 sampling locations with an average value of 52.43%, standard deviation of 2.45 and coefficient of variation of 5.95. The minimum and maximum hydraulic conductivity values were 10.30 mm h^{-1} and 8.90 mmh^{-1} with a mean value of 8.9 mmh^{-1}. The coefficient of variation was 0.49 and the standard deviation was 0.7. Skewness coefficient of 0.65 for the K data at the distribution shows a moderately skewed distribution of the K data and the distribution is positively skewed. Further use of Shapiro – wilk statistics and frequency distribution curves (Figure 4) shows that there is enough evidence to suggest that the data do not follow a normal distribution at 0.05 significant levels. (Elnagger *et al*., 2013; Taiwo *et al*., 2016).

b) Soil Chemical Properties

i. Soil pH

Table 3a and 3b shows the result of the descriptive statistics of soil chemical properties present for the upper, middle and the lower depth of the soil at the study site. Figure 5 shows the spatial distribution of hydrogen ion concentration across the study for the upper, middle and lower depth of the study area. The mean pH value of the soil in the study site was found to be 5.65, 5.64 and 5.72 for depth 10 cm, 20 cm and 30 cm respectively which is found to be slightly acidic. Optimum pH for most agricultural crops falls between 6.0 and 7.0 because nutrients are more available at pH about 6.5(Ajayi *et al*., 2010; Omotade and Alatise, 2017). Therefore makes the study area fairly suitable for the cultivation of agricultural crops as the pH across the site falls around the optimum value.

Table 3a: The descriptive statistics of soil chemical properties at the study Area at 10, 20 and 30 cm depths respectively

Variables/statistics	pH			P (mg/kg)			N (cmol/kg)			K (cmol/kg)		
Depths, cm	10	20	30	10	20	30	10	20	30	10	20	30
Mean	5.65	5.64	5.72	3.90	3.53	2.97	0.34	0.30	0.31	0.58	0.49	0.43
Median	5.60	5.75	5.76	4.08	2.65	2.75	0.33	0.31	0.30	0.59	0.42	0.42
StDev	0.21	0.26	127.07	1.74	1.65	0.99	0.04	0.05	0.04	0.12	0.19	0.16
CV	0.04	0.07	16147.07	3.04	2.72	0.97	0.00	0.00	0.00	0.01	0.04	0.03
Kurtosis	1.27	-0.49	20.00	-1.13	-1.27	5.68	-1.04	0.19	-1.57	0.81	1.20	-0.27
Skewness	-0.43	-0.64	4.47	0.16	0.68	2.18	0.20	-0.68	0.17	-0.80	1.42	0.77
Range	0.86	0.92	568.73	4.99	4.86	4.28	0.13	0.18	0.10	0.46	0.68	0.54
Min	5.10	5.10	5.27	1.71	1.71	1.92	0.27	0.20	0.26	0.26	0.22	0.22
Max	5.96	6.02	574.00	6.70	6.57	6.20	0.40	0.38	0.36	0.72	0.90	0.76
Count	20	20	20	20	20	20	20	20	20	20	20	20

Table 3b: The descriptive statistics of soil chemical properties at the study Area at 10, 20 and 30 cm depths respectively

Variables/statistics	CEC (cmol/kg)			Na (cmol/kg)			Ca (cmol/kg)			Mg (cmol/kg)		
Depths, cm	10	20	30	10	20	30	10	20	30	10	20	30
Mean	9.82	9.08	8.79	0.64	0.31	0.27	2.52	2.60	2.54	1.17	1.19	1.20
Median	9.93	8.73	8.43	0.42	0.30	0.23	2.20	2.55	2.40	1.10	1.20	1.20
StDev	1.22	1.70	1.98	0.52	0.07	0.13	0.51	0.21	0.39	0.36	0.09	0.22
CV	1.49	2.89	3.92	0.27	0.01	0.02	0.26	0.05	0.15	0.13	0.01	0.05
Kurtosis	0.05	0.06	-0.16	2.21	0.10	0.23	0.05	-0.36	0.11	1.67	0.66	0.17
Skewness	-0.26	1.12	1.04	1.88	0.91	1.14	1.25	0.87	0.67	1.70	0.21	0.61
Range	5.08	5.14	5.60	1.59	0.26	0.43	1.50	0.60	1.30	1.10	0.40	0.80
Min	7.10	7.06	6.85	0.23	0.20	0.13	2.10	2.40	2.00	0.90	1.00	0.90
Max	12.18	12.20	12.45	1.82	0.46	0.56	3.60	3.00	3.30	2.00	1.40	1.70
Count	20	20	20	20	20	20	20	20	20	20	20	20

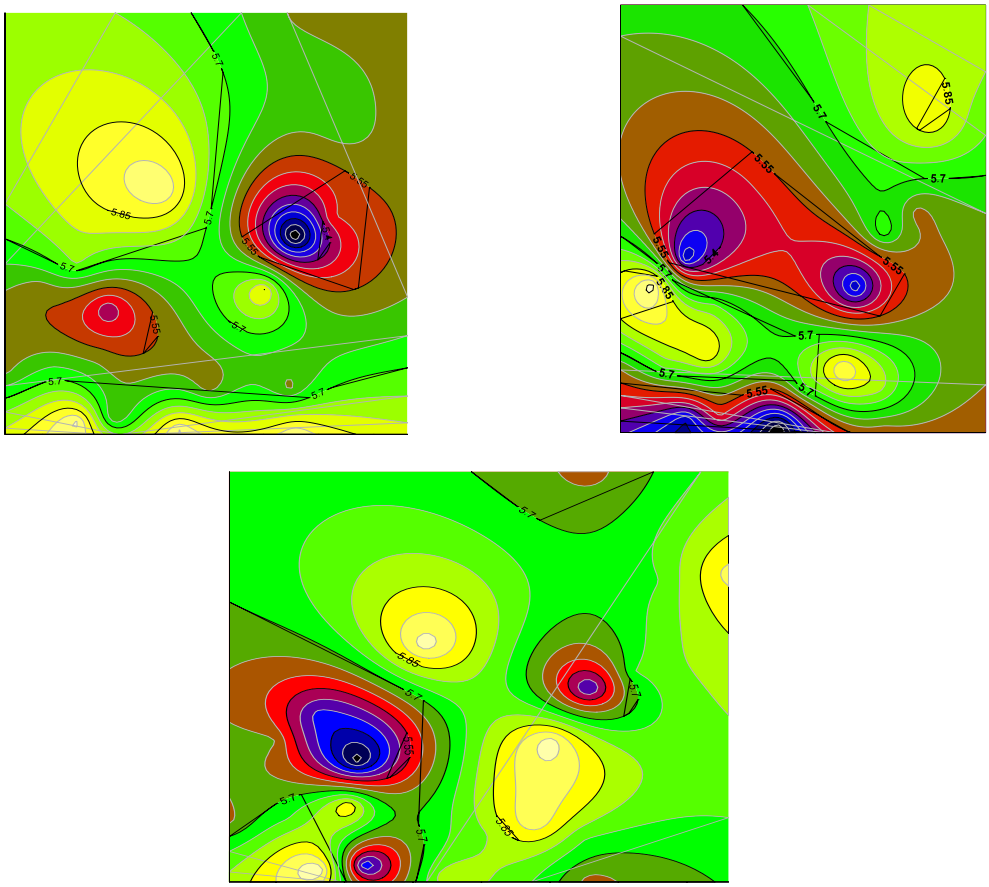


Figure 5: Spatial distribution map of hydrogen ion concentration at the study area

ii. *Cations exchange capacity (CEC)*

The CEC's across the study area spatially varied within the range of 7.01 to 12.45cmol/kg, with the average value of 9.82±1.22 and CV of 1.49 (Figure 6). The values of the soil CEC at the study area fell within the medium range based on this classification since most their values fell below the standard value of 12cmol/kg (Adepetu *et al*., 1979: Elnagger *et al*., 2013). The presence of these CEC values is influenced by high clay content, organic matter and the soil pH (Noma *et al*., 2005:Taiwo *et al*., 2016).

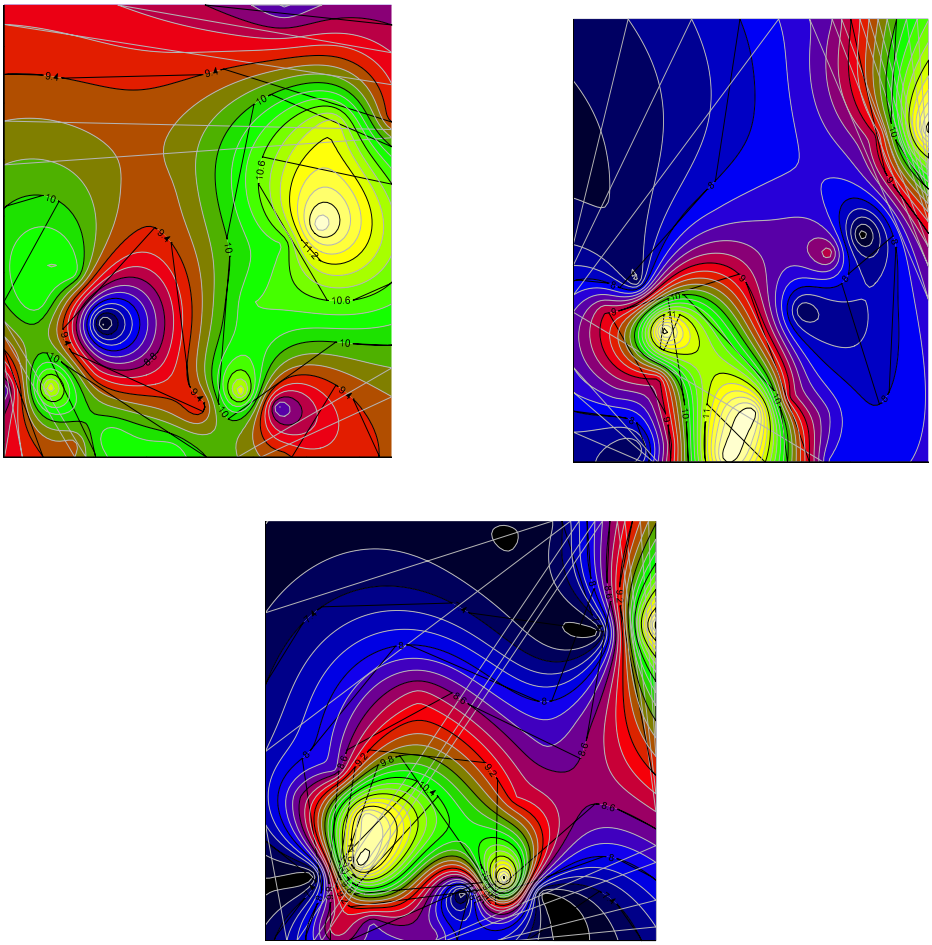


Figure 6: Spatial distribution map of Cations exchange capacity (CEC) at the study area

iii. *Soil organic matter content (OM)*

Organic matter (OM) contents can be used as physical or chemical soil properties. They are used as physical soil properties, when we refer to them as soil components and their effect on physical properties. Also, they are used as chemical soil properties due to their great effects on chemical properties. In this work they were studied under chemical properties. Soils in Crop Soil and Pest management research farm were poor in their organic matter content. The Organic matter (OM) content found in the study area varied from low (2.88%) to high (3.97%).

The spatial distribution of OM in the CSP research farm is illustrated in Fig 4.4. About 60% of soils in the research farm had average values less than 2.9%, about 40% had values between 3.4 and 3.9%. The lower values were generally associated with coarse-textured soils, whereas the higher values were linked with medium to fine varied from 2.85 to 3.39% with an average of 3.54±0.26% with CV of 0.07 (Figure 7).

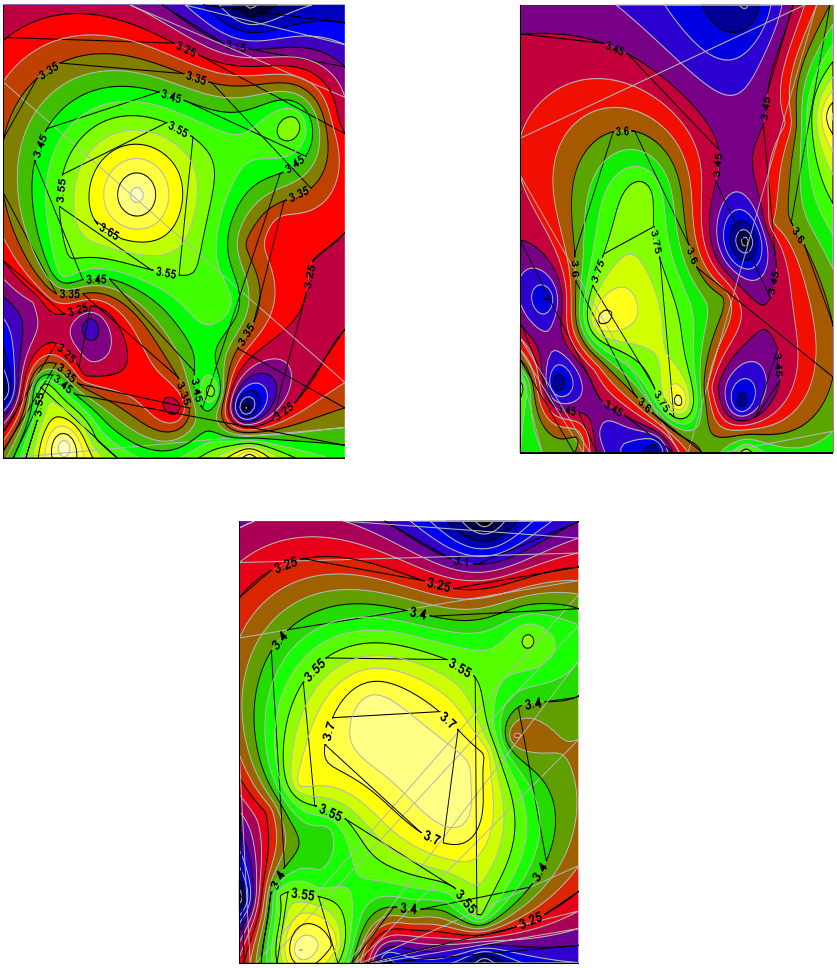


Figure 7: Spatial distribution map of soil organic matter content at the study area

iv. *Soil potassium content*

The spatial map on Figure 8 showed the distribution of potassium on the field at both 10 cm, 20cm and 30 cm deep. High variability of potassium values distribution between the range 0.64 mg/kg to 0.72 mg/kg were observed at the middle south and north eastern region of the field at depth 10 cm, at the core west at middle layer with range values of 0.75 mg/kg to 0.9 mg/kg. Moderate potassium values distribution between the range of 0.4 mg/kg to 0.56 mg/kg stretched from the North West to the south eastern part of the field at depth 10 cm and were observed at the western part of the field at 20 cm depth. Soils with high clay content and organic material can hold or have good reserves of potassium. Low potassium values between the ranges of 0.28 mg/kg to 0.35 mg/kg dominated eastern part of the field at every depth. Deficiency of potassium in soil is as a result of higher rainfall because potassium is a mobile nutrient that leaches in sandy soil. (Fasinmirin and Olorunfemi, 2013)

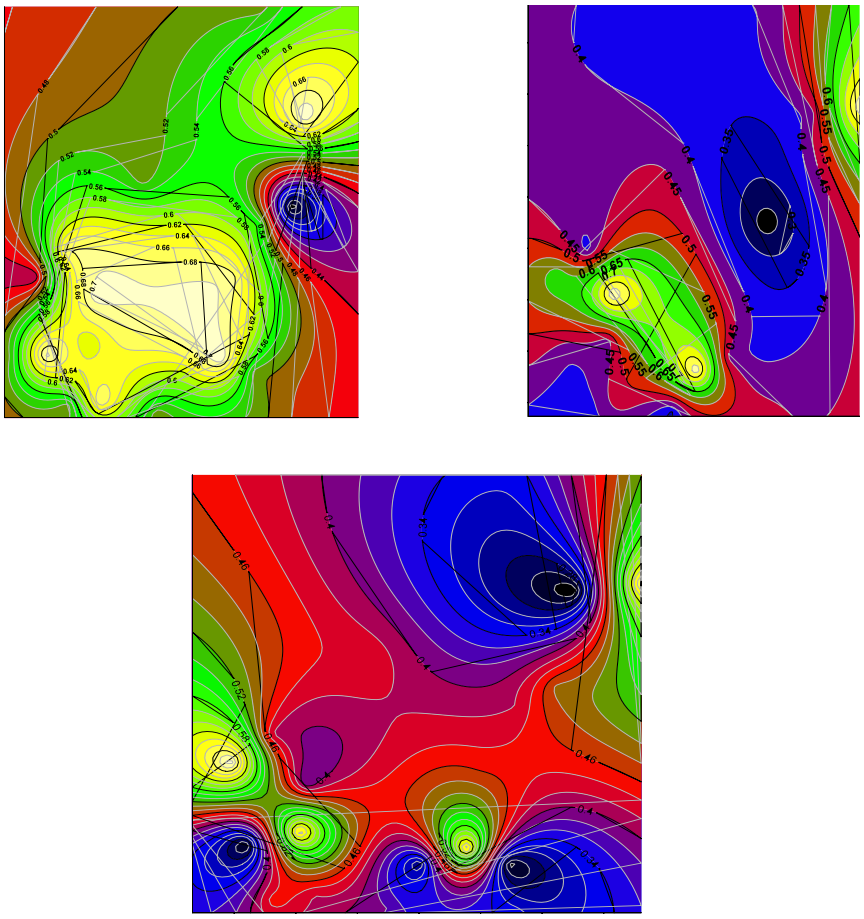


Figure 8: Spatial distribution map of soil potassium at the study area

v. *Spatial variability of the soil phosphorus*

In Figure 9, there is high phosphorus content at the eastern part stretching towards the western part and at the south eastern end but with a smaller distribution in the western southern part between the range of 5.4 mg/kg and 6.6 mg/kg. The phosphorus is moderate at the south western region between the range of 3.8 mg/kg and 5.06 mg/kg. Phosphorus is low at the north western region stretching to the south western corner between the range of 1.7 mg/kg and 3.4 mg/kg. Spatial distribution of soil type and slope causes phosphorus loss due to erosion and run off which was estimated in some part of the field.

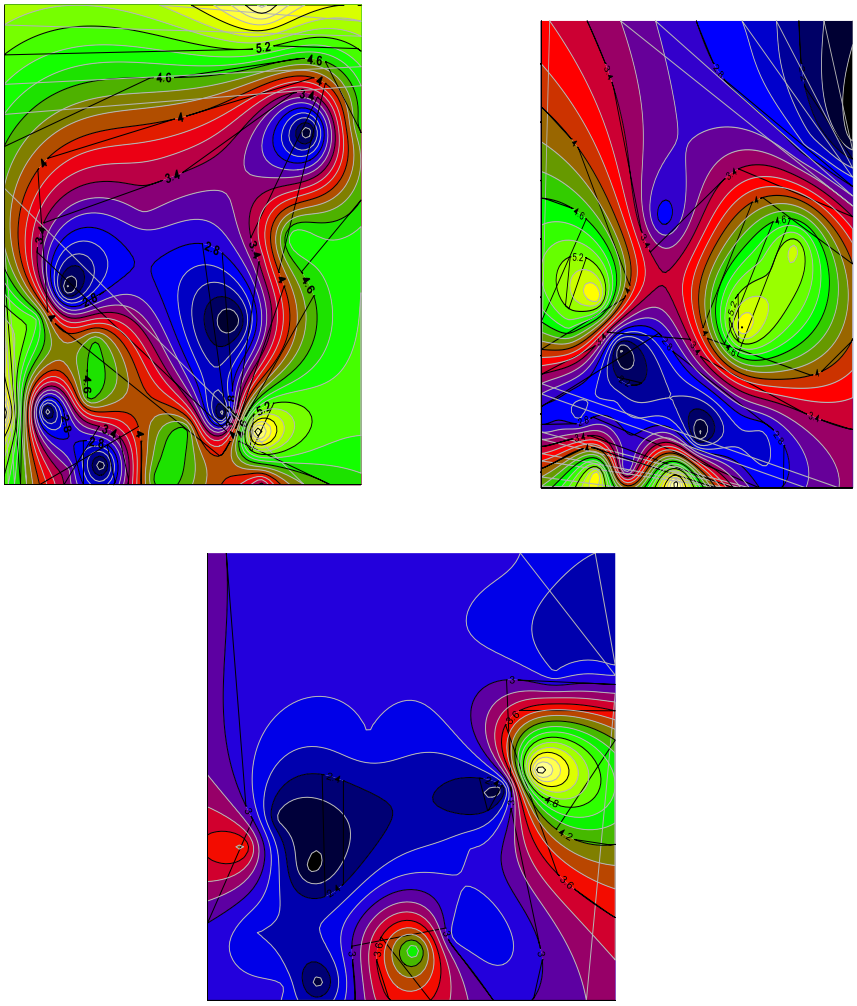


Figure 9: Spatial distribution map of soil phosphorus at the study area

vi. *Spatial variability of the soil nitrogen*

Figure 10 showed the spatial pattern of nitrogen in the soil. High nitrogen values between the ranges of 0.37% to 0.4% were observed at the southern region of the field in a small proportion. Moderate nitrogen values between the ranges 0.32% to 0.36%stretched from the North West, eastern and to the south eastern region of the field. Low nitrogen values between the ranges of 0.27% to 0.30% stretched from the western region towards the south eastern region at a larger distribution. According to Isirimah and Igwe (2003) in Omotade and Alatise (2017) low content of nitrogen in the soil is as a result of leaching caused by erosion and low organic matter.

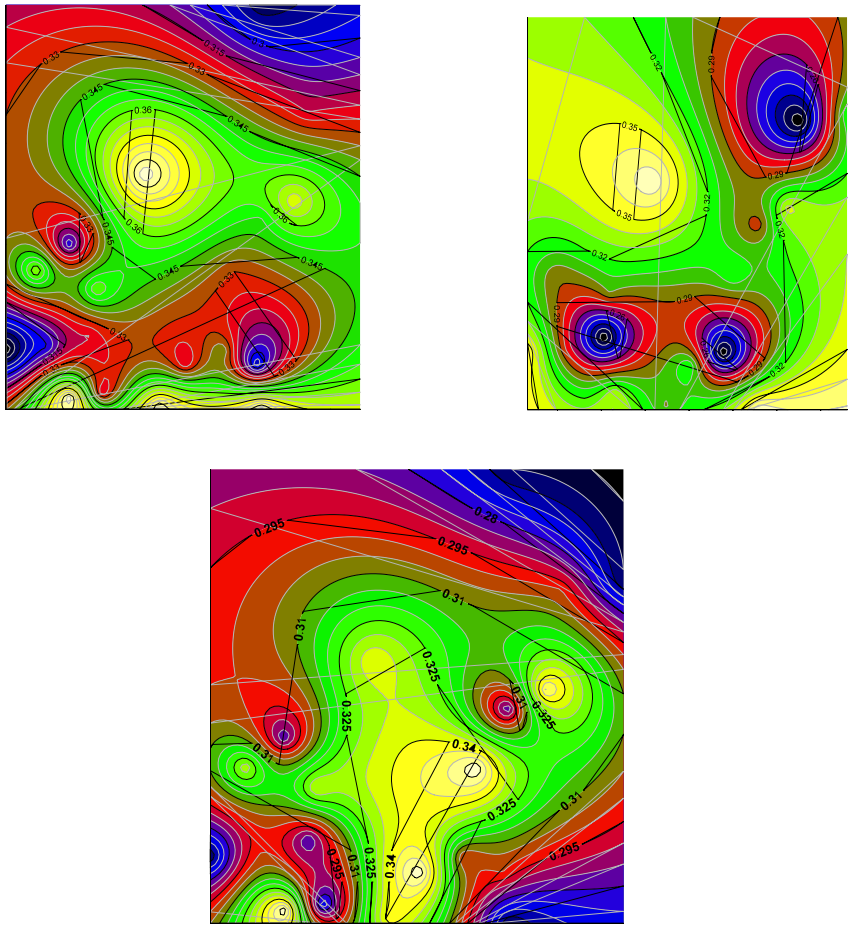


Figure 10: Spatial distribution map of soil nitrogen at the study area

The deduced values of the Phosphorus (P), Nitrogen (N), and Potassium (K). The differences between the values of K at all different points in the soil were not significant compared N, Ca, P and Mg as wide variability occurred in their values. Also the average content of Ca was relatively far higher than that of Mg with values ranging from 2.10 to 3.90 cmol/kg. It varied from 0.14 to 1.46% with an average of 0.74%. The distributions of the average values of other trace nutrients like Calcium, Sodium and Magnesium are respectively presented in Figure 11 to13for the upper, middle and lower depth of the study area.

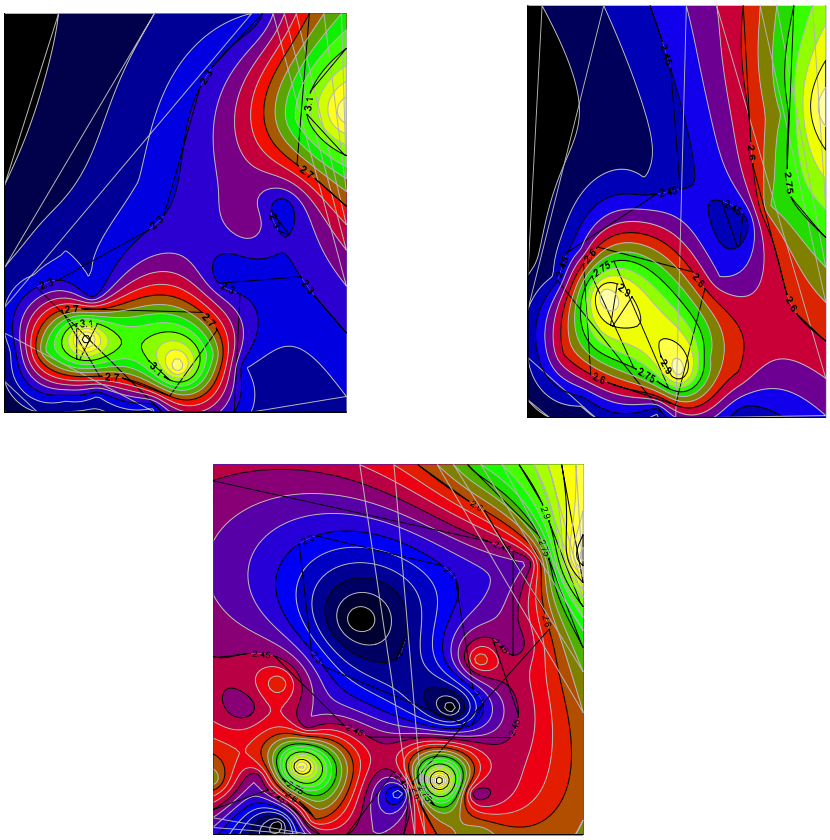


Figure 11: Spatial distribution map of soil calcium at the study area

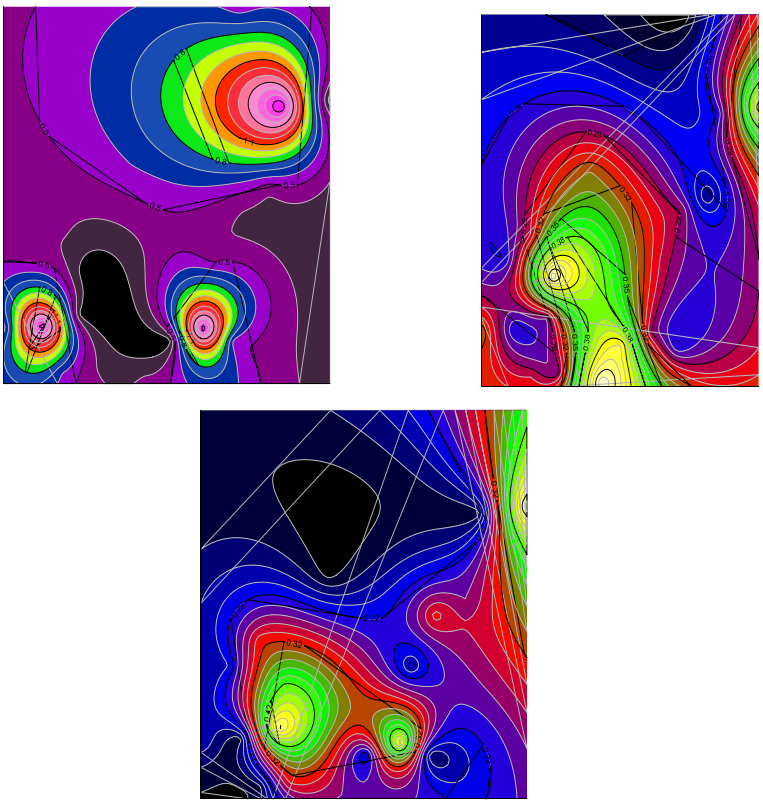


Figure 12: Spatial distribution map of soil sodium at the study area

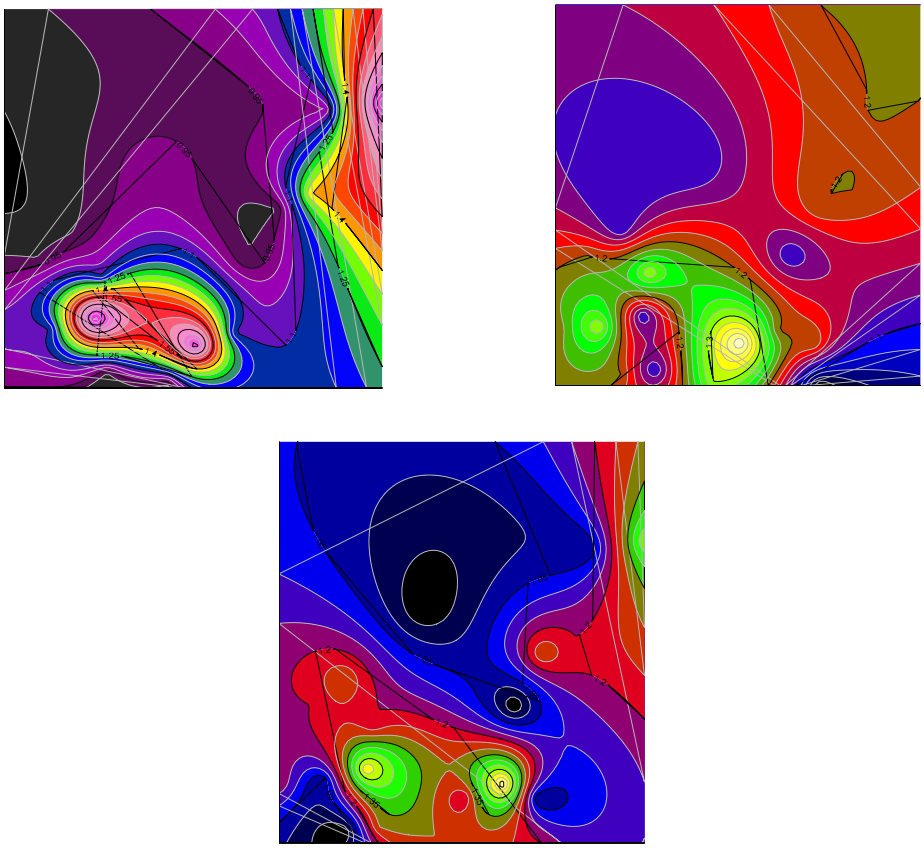


Figure 13: Spatial distribution map of soil magnesium at the study area

c) *Relationship between the Soil Properties*

i. *Relationship between bulk density and soil porosity*

The Figure 14 below showed the relationship given by the equation y = -0.553ln(x) + 0.6581with a Coefficient of Determination (R^2 = 0.9999) which indicates a strong degree of correlation but an inverse relationship between the bulk density and soil porosity. This means that the Bulk Density predicted 99.9% of the variation captured by the Soil Porosity in the study area. Therefore the model shows that the higher the bulk density of the soil the lower the percentage pore space in the soil irrespective of the depth of the soil. This observation agrees with the work of Mapa *et al*. (1986), Taiwo *et al*. (2016) and Omotade and Alatise (2017).

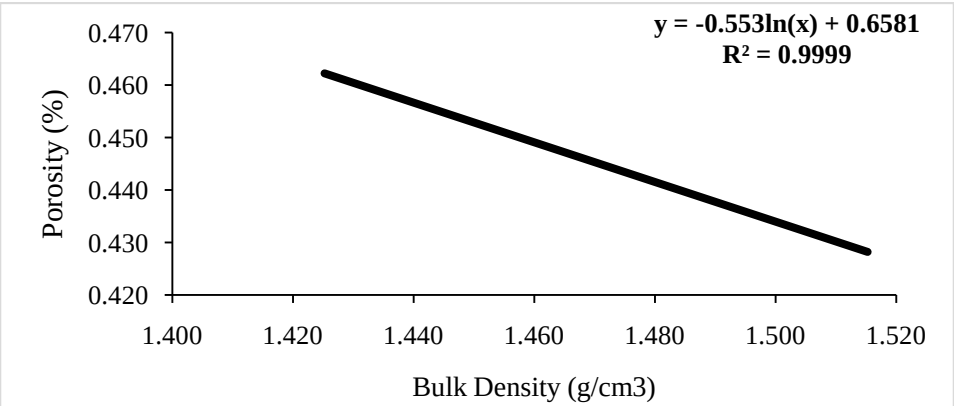


Figure 14: Relationship between Bulk Density and Soil Porosity

ii. *Relationship between soil hydraulic conductivity and soil water holding capacity with the depth*

The Figure 15 to16 below shows the Relationship between soil hydraulic conductivity and soil water holding capacity with the depth given by the equation y = $-0.0000x^2 + 0.0001x + 0.0081$ and y = $-0.0116x^2 + 0.4806x + 48.788$ respectively with a Coefficient of Determination (R^2 = 1.0) each which

indicates a strong degree of correlation. This means that the depth predicted 100% of the variation captured by the soil hydraulic conductivity and soil water holding capacity in the study area. The two parameters affect infiltration of water into the soil and significantly determine the type of irrigation system to be used on the study site. Taiwo *et al*. (2016): Omotade and Alatise (2017).

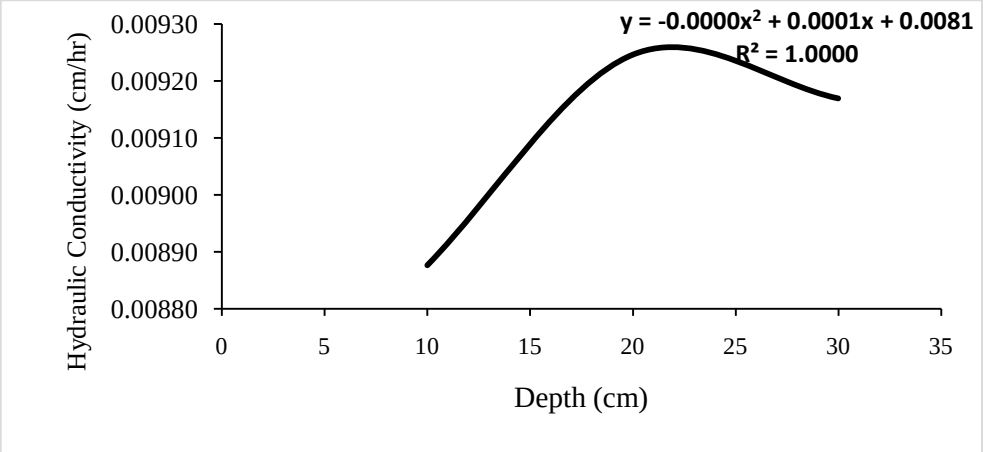


Figure 15: Relationship between Hydraulic Conductivity (cm/hr)and Depth

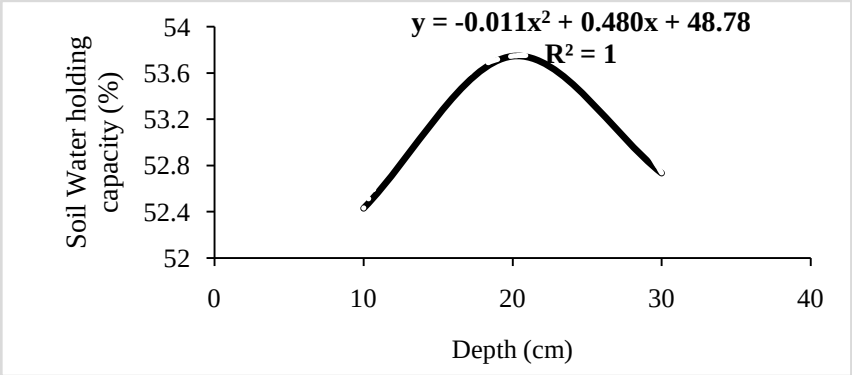


Figure 16: Relationship between Water holding capacity and Depth

iii. *Relationship between the soil moisture content and water holding capacity*

The Figure 17shows the relationship of a model given by the equation $y = -0.063x^2 + 1.7368x + 41.825$ with a Coefficient of correlation ($R^2 = 1$) which indicates an inverse variations and a very strong degree of correlation. This means that the moisture content predicted 100% of the variation captured by the water holding capacity in the study area. Hence the water holding capacity of the soil in the study depends on the soil moisture content of the soil. This observation is in line with the works of Omotade and Alatise (2017). Meanwhile, values for the water holding capacity and soil moisture content at the experimental field are similar to those reported by Taiwo *et al*. (2016) and Omotade and Alatise (2017)

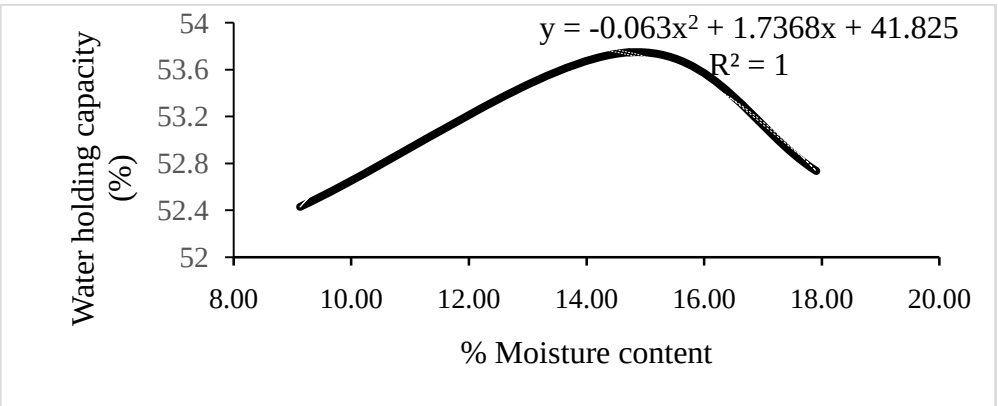


Figure 17: Relationship between soil moisture content and the soil water holding capacity

iv. *Relationship between the soil nitrogen and phosphorus*

The Figure 18shows the relationship given by the equation y = 0.0295x + 0.2129 with a Coefficient of Determination (R^2 = 0.4908) which indicates a weak degree of correlation. This means that the soil nitrogen cannot predict accurately the quantity in cmol/kg of soil phosphorus in the study area. This observation negates the one reported by Omotade and Alatise (2017) which gives the coefficient of correlation of about 92%. This observation could be as a result of the class of soil found in the study area and the dominating plant growing on the field. This can determine the quality and type of organic fertilizers that can be applied to crops grown in the study area.

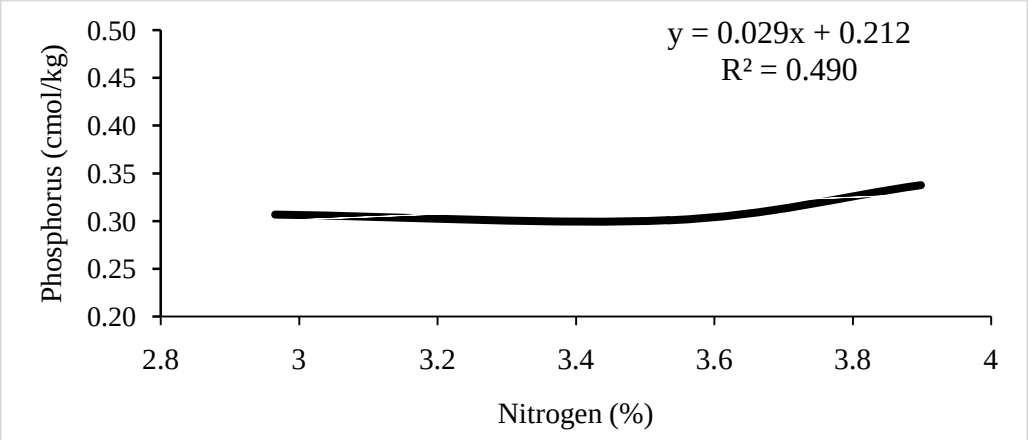


Figure 18: Relationship between Nitrogen (%) and Phosphorus (cmol/kg)

v. *Relationship between Soil organic matter and depth*

The Figure 19 shows an inverse relationship between the soil organic matter and depth given by the equation y = -0.0015x^2 + 0.0604x + 2.9237 with a Coefficient of Determination (R^2 = 1) which indicates a strong degree of correlation. This means that the soil organic matter reduces with the depth in the study area this. This observation could be as result of reduced microbial activities, increase and increase in bulk density through the depth and also as a result of the class of soil found in the study area and the dominating plant growing on the field. This can determine the quality, quantity and type of organic fertilizers that can be applied to crops it can also help in predicting suitable crops that can be grown in the study area.

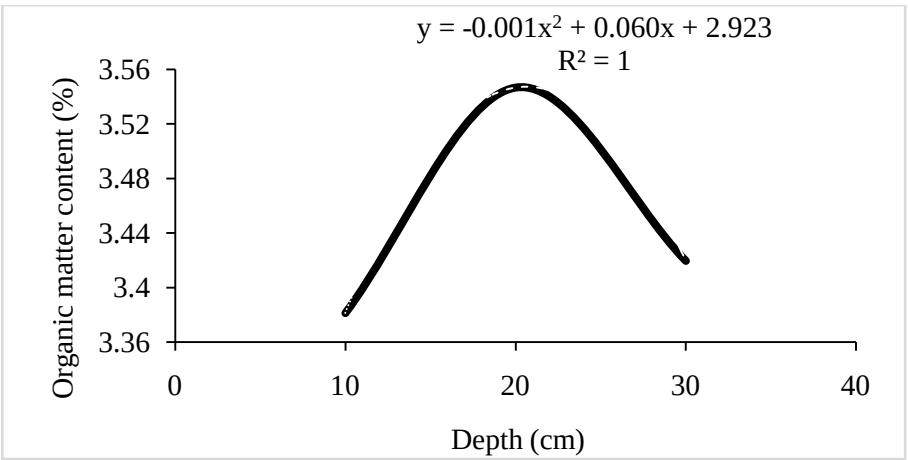


Figure 19: Relationship between Organic matter content (%) and Depth (cm)

IV. Conclusions

The physical properties of the study area as at the time of the study were found to be optimal for crop production. It was observed that about 65% of the bulk density (1.43, 1.43, 1.47, 1.48, 1.49, 1.52,) values were moderate which allows easy movement of water and air for plant development. Moreover, the measurement of the water holding capacity and the hydraulic conductivity of the field is moderate for various water management activities including selection and design of suitable irrigation systems, design of drainage system and for developing different strategies to increase crop productivity.The results of chemical properties also shows the fertility assessment and land use management practices for crop production.75% of

calcium was low and continual application of lime is needed in order to maintain the available calcium within the soil. The mean pH value of the soil in the study site was found to be 5.65, 5.64 and 5.72 for depth 10 cm, 20 cm and 30 cm respectively which is found to be slightly acidic which are usually most productive for crop growth. 80% of the CEC distributed is moderate with significant clay organic matter content gives an insight into soil quality and site characteristics of good porosity or internal structure of the soil. The organic matter content is adequate, which is 64% moderate in the soil, and organic matter levels in agricultural soil can be enhanced by crop rotation, residue management and the application of farm manure or organic fertilizers.

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References Références Referencias

1. Adepetu, J.A., Adebayo A.A., Aduayi, E.A. and Alofe, G.O. 1979. A preliminary survey of the fertility status of soils in Ondo state under traditional cultivation. Ife J. Agric. 1: 134 – 149
2. Adeyemo, A. J. and S. O. Agele. 2010. Effects of tillage and manure application on soil physicochemical properties and yield of maize grown on a degraded intensively tilled alfisol in southwestern Nigeria. Journal of Soil Science and Environmental Management, 1(8): 205-216.
3. Ajayi, I.R., Gbadamosi, A.E., Mohammed, O.Z. and Sunday, A.G. (2010). A Study on Effects of Soil Physico-Chemical Properties on Cocoa Production in Ondo State. Modern Applied Sci. 4: 35- 43
4. Akbas, F. (2014). Spatial Variability of soil color parameters and soil properties in an alluvial soil. African journal of Agriculture Research, vol.9 (12), 1025-1035.
5. Burke, A. (2014). Determining Landscape Function and Ecosystem Dynamics: Contribution to Ecological Restoration in the Southern Namib Desert. Ambio, 30(1), 29-36
6. DeGomez E.R. (2015). Soil function in a changing world: the role of invertebrate ecosystem engineers. Europe Journal of Soil Biology, 33(4), 159-193
7. Douaik, A. (2011). Alication of Statistical Methods and GIS for Downscaling and Managing Crop Statistics using Hypertemporal Remote Sensing. Research Unit on Environment and Conservation of Natural Resources, National Institute of Agricultural Research (INRA), Rabat, Morocco.
8. Elnaggar, A. A., El-Hamdi, Kh. H., Belal, A.B.A. and El-Kafrawy, M.M. (2013) Soil classification of Bahariya Oasis using remote sensing and GIS techniques. J. Soil Sci. and Agric. Eng., Mansoura Univ., 4 (9), 921 – 947
9. Esler, K. J., and Cowling, R. M. (1993). Edaphic factors and competition determinants of pattern in South African karoo vegetation. South African Journal of Botany, 59(3), 287-295.
10. Fasinmirin, J. T. and Olorunfemi I. E. 2013. Soil moisture content variation and mechanical resistance of Nigerian alfisol under different tillage systems. Journal of Agricultural Engineering and Technology (JAET).
11. Fasinmirin, J. T. and I. E. Olorunfemi. 2012. Comparison of hydraulic conductivity of soils of the forest vegetative zone of Nigeria. Applied Tropical Agriculture, 17(1): 64–77.
12. Gee, G.W., and Bouder, J.W., 1986. Particle size analysis. In: Klute, A. (Ed.), Methods of soil analysis. Part 1. Physical and mineralogical methods. 2nd ed. Agronomy monography no: 9, ASA and SSSA, Madison, WI, 825-844.
13. Goovaerts, P. 1998. Geostatistical tools for characterizing the spatial variability of microbiological and physico-chemical soil properties. Biology and Fertility Soils, 27(4): 315–334.
14. Isirimah, N.O. and Igwe, C.M.A., (2003). Important ions in soil environment. Introductory soil chemistry and Biology for Agriculture and biotechnology. 27:34 – 97
15. Koech, R., Gillies, M. and Smith,R. (2010). Simulation modelling in surface irrigation systems. Southern Region Engineering Conference, 11-12 November 2010, Toowoomba, Australia. SREC2010-F3-2
16. Landsberg, J. D., Miller, E. R., Anderson, W. H., and Te, S. J. (2003). Bulk density and soil resistance to penetration as affected by commercial thinning in north-eastern Washington. Res. Pap. PNW-RP-551. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 35p.
17. Linus, J. H. (2010). Soil contamination by the tailings dump at Namib lead mine at the surrounding area. Windhoek: University of Namibia.
18. Mapa, R. B., Green R. E. and Santo L. (1986). Temporal viability of soil hydraulic- properties with wetting and drying subsequent to tillage Soil Science Society of America Journal, 50(5): 1133-1138.
19. Musa H. and Gisilanbe S.A., (2017). Difference in physical and chemical properties of soils in Yelwa-Dobora toposequence in Ganje local government Area, Adamawa state, Nigeria. Sky Journal of Soil Science and Environmental Managments. Vol. 6(1), 11-18.
20. Mzuku M., Khosla R, Reich R, Inman D, Smith F, MacDonald L. (2005). Spatial variability of measured soil properties across site-specific management

zones. Soil Sci Soc Am J. 69:1572-9. https://doi.org/10.2136/sssaj2005.0062
21. Noma, S.S., Ojanuga, A.G., Ibrahim, S.A. and Iliya, M.A. (2005). Detailed soil survey of Sokoto - Rima floodplain at Sokoto. In managing oil resources for food security and sustainable environment Proc. 29th Annual Conf. Soil Sci. Soc. Nig
22. Omotade, I.F and Alatise M.O. (2017). Spatial Variability of Soil Physical and Chemical Properties in Akure, South Western, Nigeria. Global Journal of Science Frontier Research: Agriculture and Veterinary. Vol 17.
23. Pennok, D. J. and Corre, M. D. (1994). Development and application of landform segmentation procedures. Soil and Tillage Research, 58, 151-162
24. Rahal,C.A.Moorman,T.B.,Novak,J.M.,Parkin,T.B.,Karlen,D.L.,Turco,R.F. and Konopka, A.E. (2015). Field-scale variability of soil properties in central Iowa soils. Soil Science Society America Journal 58(5):1501–1511.
25. Sanjib K. B., Kancherla S., Bezawada N. R., Ravi K. M., Arvind Kumar S, Kamireddy M, Kummari R, Parasa H, and Chandra P. (2016). Spatial variability of some soil properties varies in oil palm (Elaeis guineensis Jacq.) plantations of west coastal area of India. Solid Earth, 7, 979–993.
26. Shukla, M. K. and Lal, R. (2002). Water infiltration in soils. In R. Lal, ed. Encyclopedia of soil science. Marcel Dekker. New York. 1-3.
27. Taiwo A. A., Olufayo A. A., Fasinmirin J. T. and Olorunfemi I. E. (2016). Spatial analysis of soil hydraulic properties of an alfisol in Akure, Southwestern Nigeria. AgricEngInt: CIGR Journal. Vol. 18, No.1-19.
28. Vereecken, H., J. Maes, J. Feyen, and P. Darius. (1989). Estimating the soil moisture retention characteristic from texture, bulk density, and carbon content. Soil Science. 148(6): 389-403.
29. Vogelmann, E. S., J. M. Reichert, D. J. Reinert, M. I. Mentges, D. A. Vieira, C. A. Peixoto deBarros, and J. T. Fasinmirin. (2010). Water repellency in soils of humid subtropical climate of Rio Grande do Sul, Brazil. Soil Tillage Research, 110(1): 126-133.

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We shall provide print version of 12 issues of any three journals [as per your requirement] out of our 38 journals worth $ 2376 USD.

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The individual Fellow and Associate designations accredited by Open Association of Research Society (US) credentials signify guarantees following achievements:

- The professional accredited with Fellow honor, is entitled to various benefits viz. name, fame, honor, regular flow of income, secured bright future, social status etc.

- In addition to above, if one is single author, then entitled to 40% discount on publishing research paper and can get 10%discount if one is co-author or main author among group of authors.
- The Fellow can organize symposium/seminar/conference on behalf of Global Journals Incorporation (USA) and he/she can also attend the same organized by other institutes on behalf of Global Journals.
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- • This individual has learned the basic methods of applying those concepts and techniques to common challenging situations. This individual has further demonstrated an in–depth understanding of the application of suitable techniques to a particular area of research practice.

Note :

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- In future, if the board feels the necessity to change any board member, the same can be done with the consent of the chairperson along with anyone board member without our approval.
- In case, the chairperson needs to be replaced then consent of 2/3rd board members are required and they are also required to jointly pass the resolution copy of which should be sent to us. In such case, it will be compulsory to obtain our approval before replacement.
- In case of "Difference of Opinion [if any]" among the Board members, our decision will be final and binding to everyone.

"

Preferred Author Guidelines

We accept the manuscript submissions in any standard (generic) format.

We typeset manuscripts using advanced typesetting tools like Adobe In Design, CorelDraw, TeXnicCenter, and TeXStudio. We usually recommend authors submit their research using any standard format they are comfortable with, and let Global Journals do the rest.

Alternatively, you can download our basic template from https://globaljournals.org/Template.zip

Authors should submit their complete paper/article, including text illustrations, graphics, conclusions, artwork, and tables. Authors who are not able to submit manuscript using the form above can email the manuscript department at submit@globaljournals.org or get in touch with chiefeditor@globaljournals.org if they wish to send the abstract before submission.

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Authors must ensure the information provided during the submission of a paper is authentic. Please go through the following checklist before submitting:

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3. Ensure corresponding author's email address and postal address are accurate and reachable.
4. Manuscript to be submitted must include keywords, an abstract, a paper title, co-author(s') names and details (email address, name, phone number, and institution), figures and illustrations in vector format including appropriate captions, tables, including titles and footnotes, a conclusion, results, acknowledgments and references.
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Declaration of Conflicts of Interest

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- Findings
- Writings
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- Graphs
- Illustrations
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- Printed material
- Graphic representations
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3. Final approval of the version of the paper to be published.

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The corresponding author should mention the name and complete details of all co-authors during submission and in manuscript. We support addition, rearrangement, manipulation, and deletions in authors list till the early view publication of the journal. We expect that corresponding author will notify all co-authors of submission. We follow COPE guidelines for changes in authorship.

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Unless specified in the notification, the Editorial Board's decision on publication of the paper is final and cannot be appealed before making the major change in the manuscript.

Acknowledgments

Contributors to the research other than authors credited should be mentioned in Acknowledgments. The source of funding for the research can be included. Suppliers of resources may be mentioned along with their addresses.

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Preparing your Manuscript

Authors can submit papers and articles in an acceptable file format: MS Word (doc, docx), LaTeX (.tex, .zip or .rar including all of your files), Adobe PDF (.pdf), rich text format (.rtf), simple text document (.txt), Open Document Text (.odt), and Apple Pages (.pages). Our professional layout editors will format the entire paper according to our official guidelines. This is one of the highlights of publishing with Global Journals—authors should not be concerned about the formatting of their paper. Global Journals accepts articles and manuscripts in every major language, be it Spanish, Chinese, Japanese, Portuguese, Russian, French, German, Dutch, Italian, Greek, or any other national language, but the title, subtitle, and abstract should be in English. This will facilitate indexing and the pre-peer review process.

The following is the official style and template developed for publication of a research paper. Authors are not required to follow this style during the submission of the paper. It is just for reference purposes.

Manuscript Style Instruction (Optional)

- Microsoft Word Document Setting Instructions.
- Font type of all text should be Swis721 Lt BT.
- Page size: 8.27" x 11'", left margin: 0.65, right margin: 0.65, bottom margin: 0.75.
- Paper title should be in one column of font size 24.
- Author name in font size of 11 in one column.
- Abstract: font size 9 with the word "Abstract" in bold italics.
- Main text: font size 10 with two justified columns.
- Two columns with equal column width of 3.38 and spacing of 0.2.
- First character must be three lines drop-capped.
- The paragraph before spacing of 1 pt and after of 0 pt.
- Line spacing of 1 pt.
- Large images must be in one column.
- The names of first main headings (Heading 1) must be in Roman font, capital letters, and font size of 10.
- The names of second main headings (Heading 2) must not include numbers and must be in italics with a font size of 10.

Structure and Format of Manuscript

The recommended size of an original research paper is under 15,000 words and review papers under 7,000 words. Research articles should be less than 10,000 words. Research papers are usually longer than review papers. Review papers are reports of significant research (typically less than 7,000 words, including tables, figures, and references)

A research paper must include:

a) A title which should be relevant to the theme of the paper.
b) A summary, known as an abstract (less than 150 words), containing the major results and conclusions.
c) Up to 10 keywords that precisely identify the paper's subject, purpose, and focus.
d) An introduction, giving fundamental background objectives.
e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition, sources of information must be given, and numerical methods must be specified by reference.
f) Results which should be presented concisely by well-designed tables and figures.
g) Suitable statistical data should also be given.
h) All data must have been gathered with attention to numerical detail in the planning stage.

Design has been recognized to be essential to experiments for a considerable time, and the editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned unrefereed.

i) Discussion should cover implications and consequences and not just recapitulate the results; conclusions should also be summarized.
j) There should be brief acknowledgments.
k) There ought to be references in the conventional format. Global Journals recommends APA format.

Authors should carefully consider the preparation of papers to ensure that they communicate effectively. Papers are much more likely to be accepted if they are carefully designed and laid out, contain few or no errors, are summarizing, and follow instructions. They will also be published with much fewer delays than those that require much technical and editorial correction.

The Editorial Board reserves the right to make literary corrections and suggestions to improve brevity.

Format Structure

It is necessary that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.

All manuscripts submitted to Global Journals should include:

Title

The title page must carry an informative title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) where the work was carried out.

Author details

The full postal address of any related author(s) must be specified.

Abstract

The abstract is the foundation of the research paper. It should be clear and concise and must contain the objective of the paper and inferences drawn. It is advised to not include big mathematical equations or complicated jargon.

Many researchers searching for information online will use search engines such as Google, Yahoo or others. By optimizing your paper for search engines, you will amplify the chance of someone finding it. In turn, this will make it more likely to be viewed and cited in further works. Global Journals has compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

Keywords

A major lynchpin of research work for the writing of research papers is the keyword search, which one will employ to find both library and internet resources. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining, and indexing.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy: planning of a list of possible keywords and phrases to try.

Choice of the main keywords is the first tool of writing a research paper. Research paper writing is an art. Keyword search should be as strategic as possible.

One should start brainstorming lists of potential keywords before even beginning searching. Think about the most important concepts related to research work. Ask, “What words would a source have to include to be truly valuable in a research paper?” Then consider synonyms for the important words.

It may take the discovery of only one important paper to steer in the right keyword direction because, in most databases, the keywords under which a research paper is abstracted are listed with the paper.

Numerical Methods

Numerical methods used should be transparent and, where appropriate, supported by references.

Abbreviations

Authors must list all the abbreviations used in the paper at the end of the paper or in a separate table before using them.

Formulas and equations

Authors are advised to submit any mathematical equation using either MathJax, KaTeX, or LaTeX, or in a very high-quality image.

Tables, Figures, and Figure Legends

Tables: Tables should be cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g., Table 4, a self-explanatory caption, and be on a separate sheet. Authors must submit tables in an editable format and not as images. References to these tables (if any) must be mentioned accurately.

Figures

Figures are supposed to be submitted as separate files. Always include a citation in the text for each figure using Arabic numbers, e.g., Fig. 4. Artwork must be submitted online in vector electronic form or by emailing it.

Preparation of Eletronic Figures for Publication

Although low-quality images are sufficient for review purposes, print publication requires high-quality images to prevent the final product being blurred or fuzzy. Submit (possibly by e-mail) EPS (line art) or TIFF (halftone/ photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Avoid using pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings). Please give the data for figures in black and white or submit a Color Work Agreement form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

For scanned images, the scanning resolution at final image size ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs): >350 dpi; figures containing both halftone and line images: >650 dpi.

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Tips for Writing a Good Quality Science Frontier Research Paper

Techniques for writing a good quality Science Frontier Research paper:

1. Choosing the topic: In most cases, the topic is selected by the interests of the author, but it can also be suggested by the guides. You can have several topics, and then judge which you are most comfortable with. This may be done by asking several questions of yourself, like "Will I be able to carry out a search in this area? Will I find all necessary resources to accomplish the search? Will I be able to find all information in this field area?" If the answer to this type of question is "yes," then you ought to choose that topic. In most cases, you may have to conduct surveys and visit several places. Also, you might have to do a lot of work to find all the rises and falls of the various data on that subject. Sometimes, detailed information plays a vital role, instead of short information. Evaluators are human: The first thing to remember is that evaluators are also human beings. They are not only meant for rejecting a paper. They are here to evaluate your paper. So present your best aspect.

2. Think like evaluators: If you are in confusion or getting demotivated because your paper may not be accepted by the evaluators, then think, and try to evaluate your paper like an evaluator. Try to understand what an evaluator wants in your research paper, and you will automatically have your answer. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

3. Ask your guides: If you are having any difficulty with your research, then do not hesitate to share your difficulty with your guide (if you have one). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work, then ask your supervisor to help you with an alternative. He or she might also provide you with a list of essential readings.

4. Use of computer is recommended: As you are doing research in the field of science frontier then this point is quite obvious. Use right software: Always use good quality software packages. If you are not capable of judging good software, then you can lose the quality of your paper unknowingly. There are various programs available to help you which you can get through the internet.

5. Use the internet for help: An excellent start for your paper is using Google. It is a wondrous search engine, where you can have your doubts resolved. You may also read some answers for the frequent question of how to write your research paper or find a model research paper. You can download books from the internet. If you have all the required books, place importance on reading, selecting, and analyzing the specified information. Then sketch out your research paper. Use big pictures: You may use encyclopedias like Wikipedia to get pictures with the best resolution. At Global Journals, you should strictly follow here.

6. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right? It is a good habit which helps to not lose your continuity. You should always use bookmarks while searching on the internet also, which will make your search easier.

7. Revise what you wrote: When you write anything, always read it, summarize it, and then finalize it.

8. Make every effort: Make every effort to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in the introduction—what is the need for a particular research paper. Polish your work with good writing skills and always give an evaluator what he wants. Make backups: When you are going to do any important thing like making a research paper, you should always have backup copies of it either on your computer or on paper. This protects you from losing any portion of your important data.

9. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several unnecessary diagrams will degrade the quality of your paper by creating a hodgepodge. So always try to include diagrams which were made by you to improve the readability of your paper. Use of direct quotes: When you do research relevant to literature, history, or current affairs, then use of quotes becomes essential, but if the study is relevant to science, use of quotes is not preferable.

10. Use proper verb tense: Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

11. Pick a good study spot: Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

12. Know what you know: Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

13. Use good grammar: Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

14. Arrangement of information: Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

15. Never start at the last minute: Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

16. Multitasking in research is not good: Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

17. Never copy others' work: Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

18. Go to seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

19. Refresh your mind after intervals: Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

20. Think technically: Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.

21. Adding unnecessary information: Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

22. Report concluded results: Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

23. Upon conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

Final points:

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

The introduction: This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

The discussion section:

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear: Adhere to recommended page limits.

Mistakes to avoid:

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.
- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

Title page:

Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

Abstract: This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

Reason for writing the article—theory, overall issue, purpose.

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

Approach:

- Single section and succinct.
- An outline of the job done is always written in past tense.
- Concentrate on shortening results—limit background information to a verdict or two.
- Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

Introduction:

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

The following approach can create a valuable beginning:

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- Briefly explain the study's tentative purpose and how it meets the declared objectives.

Approach:

Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

As always, give awareness to spelling, simplicity, and correctness of sentences and phrases.

Procedures (methods and materials):

This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order, but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt to give the least amount of information that would permit another capable scientist to replicate your outcome, but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section.

When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

Materials may be reported in part of a section or else they may be recognized along with your measures.

Methods:

- Report the method and not the particulars of each process that engaged the same methodology.
- Describe the method entirely.
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- Simplify—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

Approach:

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

What to keep away from:

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings—save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.

Content:

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or manuscript.

What to stay away from:

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

Approach:

As always, use past tense when you submit your results, and put the whole thing in a reasonable order.

Put figures and tables, appropriately numbered, in order at the end of the report.

If you desire, you may place your figures and tables properly within the text of your results section.

Figures and tables:

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

Discussion:

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an argument should be.

Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully described.

Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact, you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."

Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

- You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

When you refer to information, differentiate data generated by your own studies from other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

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	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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