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Research Article **Open Access**

Effect of Stocking Density Stress on the Hematological Profile of *Oncorhynchus mykiss*

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Abstract The present research aimed at the investigation into the effect of stocking density on the hematological response of *Oncorhynchus mykiss* maintained in flow through condition. The stock having a weight of 520.22 ± 48.20 g and 580.25 ± 52.2 g were stocked in flow through FRP tanks at the stocking density of 38 kg/m^3 and 30 kg/m^3 respectively. In order to collect blood sample for analysis, the blood was collected through cardiac puncture. Red blood cell counts (RBCc), hematocrit values (Hct), hemoglobin concentration (Hb), were analyzed through haemoanalyser, while as mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH) and mean corpuscular hemoglobin concentration (MCHC) were calculated through standard formulas. Differences in hematological parameters were statistically analyzed by Student's T-Test. The stocking density stress was evident from the significant increase (p<0.05) in RBC, Hb, Ht, MCV and insignificant decrease (p>0.05) in MCH and MCHC.
Keywords *Oncorhynchus mykiss, Stocking Density, Hematological Indices*

1. Introduction

Trout are the most commonly cultured fish in the world, and are a food staple in many parts of Africa, Asia and South America. Aquaculture of trout, as with other species of finfish, is adversely affected by production related disorders and infectious diseases, among which the most important physical factor is the stocking density. In this study, we determined reference intervals for hematologic analytes in cultured trout. We also evaluated clinical chemistry results from a small group of trout raised under different culture conditions. To our knowledge, this is the first study to determine complete hematologic and clinical chemistry results for trout from Kashmir province of Jammu and Kashmir State, India and to report the values as reference intervals suitable for diagnostic use.

There is sharp rise in pisciculture in inland waters all over the country. Farmers find it economically more profitable and physically less cumbersome and less demanding; than traditional agriculture practices. It is here, that with increase in pisciculture, problems of aquatic environmental management and that of fish disease management are posing a serious challenge to fish biologist, fish culturists and experts of the subject. The hematology offers one of the easiest, cheapest and most reliable methodologies to diagnose the status of fish health and treat them.

Stocking density is an important management issue for a good husbandry practice, higher growth, disease free stock and better economic returns. There has been little work on the exact stocking density modules based on the assessment of the impact of various physic chemical factors on the growth of rainbow trout. An exact stocking density of rainbow trout in fresh flowing waters depends on the water flow, water quality, physical characteristics, plankton biomass, and the artificial feeding schedules in rearing spaces. However the stocking stress analysis is a prerequisite to get an idea about the hematological variation due to stress, in turn depicting the health status of rainbow trout at lower and higher density.

2. Materials and Methods

2.1. Stocking Density

The rainbow trout table size fish weighing 520.22 ± 48.20 g and 580.25± 52.2 g were stocked in two different tanks in replicas in the stocking density of 38 kg/m^3 and 30 kg/ m^3 (Table 1), the treatments were named as R1 and R2 and the replicas as R3 and R4. The rainbow trout stock was 2 years old reared in fibre tanks with continue flow through system. The experiment lasted for 90 days. During the tenure of research, care was taken to clean the tanks through water jet systems, avoiding any physical stress to the livestock. The feeding of the fishes was done at the rate of 2% of the body weight. No chemical treatment or change in any physical feature of water was undertaken during the experimental period, ensuring complete effect of stocking density as the sole physical factor altering hematology.

2.2. Blood Sampling and Analysis

0.5 ml of blood was sampled from 10 fish of each tank by caudal venous puncture using lithium heparin as anticoagulant at the beginning and the end of the experimental trial. Blood was analysed with routine method used in fish hematology [4]. The red blood cell counts (RBC x 10^6/µl) were determined by counting the erythrocytes from 5 small squares of Neubauer hemocytometer using Vulpian diluting solution. The hematocrit (PCV, %) was determined by duplicate using heparinised capillary tubes centrifuged for 4 minutes at 13000 rpm in a micro hematocrit centrifuge. Red blood cell counts (RBCc), hematocrit values (Hct), hemoglobin concentration (Hb), were analysed through haemoanalyser, while as mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH) and mean corpuscular hemoglobin concentration (MCHC) were calculated through standard formulas [5, 6].

2.3. Statistical Analysis

Student t-test was used to analyse the difference between the treatment groups and the results were expressed as mean±SD.

3. Results and Discussion

The present investigation into the effect of higher stocking density on the health status of rainbow trout (*Oncorhynchus mykiss*) revealed some interesting results. The same could be used to assess the appropriate quantity of fish biomass to be kept in each cubic metre of water for its better growth and stress free metabolic activity. The present finding is a baseline for further research in the field of fish management and husbandry practices. Same investigation could form a basic hematological profile for better understanding of stress, if any, to the livestock in the fish farm, by any of the physical or chemical parameters.

Table 1: *Biometric and Statistical Data*

Experimental	R1	R2	R3	R4
Trial	**T1**	**T2**	**T2**	**T1**
Total Biomass (g)	10400	10600	12000	11800
Number of Individuals	20	20	20	20
Average Weight (g/ex)	520.00	530.20	600.00	590.00
Standard Deviation	44.51	36.22	24.26	29.85
Coefficient of Variation	0.22	0.16	0.12	0.08

R1 – experimental version of the stocking density was 38 kg/m^3
R2 – experiment version of the stocking density was 30 kg/m^3

Table 2: *Changes in Hematological Parameters of Rainbow Trout during the Experiment*

Experimental Trial		Hematological Parameters (Average ± Standard Deviation)					
		Ht (%)	Hb (g/dl)	RBC x10^6/µl	MCV (µm^3)	MCH (pg)	MCHC (g/dl)
R1	T1 i	40±6.8	7.45±1.00	1.09±0.13	361.20±28.21	68.41±3.13	19.00±0.8
	T1 f	52±2.6	8.85±0.38	1.24±0.07	420.64±20.36	71.35±4.74	16.99±1.2
R1	T1 i	35±8.6	7.75±0.75	0.99±0.15	354.88±97.16	79.6±11.27	23.42±4.91
	T1 f	50±4.5	9.75±1.59	1.30±0.14	389.40±58.70	76.13±18.26	19.35±1.59
R2	T2 i	33±4.9	8.13±0.40	1.10±0.15	343.33±49.60	77.17±7.42	22.88±3.4
	T2 f	55±3.4	11.13±0.26	1.42±0.07	364.81±54.61	78.44±6.46	22.04±4.22
R2	T2 i	33±6.3	7.42±1.39	1.06±0.14	313.40±26.39	69.54±4.93	22.35±2.53
	T2 f	50±8.2	11.32±0.88	1.46±0.062	342.93±47.76	77.22±5.23	23.08±4.36

i, f – beginning and the end of experiment

The ANOVA of haemoglobin in fish exposed to stocking density stress revealed the following:

The quantity of Hb for the trout in R1 had an average of 8.85 and 9.75 g/dl, recording a slight increase as opposed to the initial moment, when it was 7.45 and 7.75 g/dl.

- In the case of the second experimental value, R2, the increase of the quantity of Hb was higher ($p<0.05$), recording an average of 11.13 and 11.32 g/dl, as opposed to the initial moment, when the average was 8.13 and 7.42 g/dl respectively (Table 2).

Nicula (2004) reported that the physical or environmental stress causes the rapid increase in the concentration of Hb, due to the erythrocytes collection from the spleen and the hemoconcentration due to the loss of plasmic water [9]. The quantity of hemoglobin from the blood of trout in experimental variant T2f, greatly decreased ($p<0.05$) in contrast to T2f. The important reduction of hemoglobin can modify the oxygen quantity from tissues and can thus lead to the slowing of the metabolic activity and hence the meager production of energy [10]. The important decrease of the hemoglobin can also be caused by the increase in the destruction rate of Hb or the reduction of its synthesis rate [11].

Haematocrit showed the same trend of increase as in case of haemoglobin. In contrast to initial value, when there were average values of 40±6.9 and 35±8.6 %, the trout from T1 and T2 registered an average 52±2.7% and 50±4.6%, augmenting from a statistic point of view ($p<0.05$). In the case of the second variant (R2), the increase in the value of Ht ($p<0.05$) was similar to that in the high density variant (R1), with an average of 55±3.5 and 50±8.2 %, while at the initial moment it had an average of only 33±4.9%. When the two experimental variants were compared, the value of the hematocrit was constant, with unimportant statistic differences.

The increase in hematocrit value is attributable to the higher viscosity of blood [9]. The number of erythrocytes also showed an increase pertinent to the increase in haemoglobin concentration in higher stocking density. There was an increase in hematocrit in case of both experimental values in contrast to the initial value, related to the increase in quantity of haemoglobin and hematocrit.

Similar results were obtained by Valenzuela A.E. [12] in his work concerning the physical stress, caused by the increase in temperature and the continuous use of light, on the physiology of the blood for *Onchorhynchus mykiss*. The spleen is considered as the depositing place for erythrocytes [13], being able to contract by adrenergic stimuli [14]. When the two experimental variants were compared, a noticed reduction ($p=0.01$) of the number of erythrocytes in the blood of the trout was observed under the influence of density, related to the reduction of haemoglobin quantity. The reduction of the haemoglobin blood concentration has an impact on the cardiac function because the circulating needs and the cardiac rhythm, necessary in order to deliver O_2 to tissues, grow significantly while the hematocrit decreases [9].

The erythrocyte constants (MCV, MCH, MCHC) for the blood of the trout were calculated using the values of Hb, RBC and PCV and putting the values in the standard formulas. During the present experiment, MCV significantly increased in high stocking density group as compared to the low stocking density. In case of high density group, MCV varied between 420.64 ± 20.36 μm^3 and 389.4±58.70 μm^3 as compared to the variant with a smaller density and with an average of 364.81 ± 54.61 and 342.93 ± 47.76 μm^3.

In contrast to MCV, the value of MCH was relatively constant as compared to the initial value, but insignificantly decreased ($p>0.05$) in high stocking density group, with a value of 71.35 ± 4.74 pg. MCHC had a similar value to MCH, insignificantly decreasing ($p>0.05$) with 23% in high stocking density, with a value of 71.35 ± 4.74 pg. Even if the erythrocytes from the blood of the trout in R1 significantly decreased, the adaptation response of the blood to the stocking density was promptly concretized into MCV. But this reaction was not efficient because MCH, as well as MCHC, decreased insignificantly ($p>0.05$). It is possible that modifications are the result of the stressing effect of stocking density above the optimal limit.

4. Conclusion

The results of the present experiment revealed that blood is an important component which reflects/adopts the stress response and projects it through the changes in various parameters. In case of high stocking density group, a significant ($p<0.05$) increase in the number of erythrocytes, hematocrit and the quantity of hemoglobin was recorded. Conclusively blood parameters are the best indices of stress in fish, which give the easy and best estimation of the stress due to various physical or chemical factors.

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Development of Crops Featured Commodities Application in Java and Sumatera Island Based on Geographic Information System

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Abstract Indonesia is an archipelago country that some of the population work as farmers. Farmers can plant excellent commodities such as rice, corn, potato tubers, bulbs timber, soybeans, green beans, and peanuts on the available land. All this time, Indonesian people only know the agricultural land that has good quality found in big cities, in any small town also has land that produces the same quality of food crops. Advanced research goal is to develop an application that has been designed to make distribution of food crops. This research-based Geographic Information System (GIS) to determine location of food crops distribution in the islands of Java and Sumatera. This research produced an application that has data base more complete and it can be accessed by internet and mobile phones. Making it easier for the user or society to know distribution of food plants in Java and Sumatera, then society can find out information about location which has the desired crops.
Keywords *Application; Commodities; Crops; Information Systems*

1. Introduction

Indonesia is an archipelago country that some of population work as farmers. Farmers can plant excellent commodities such as rice, corn, potato tubers, bulbs timber, soybeans, green beans, and peanuts on the available land. All this time, Indonesian people only know the agricultural land that has good quality found in big cities, in any small town also has land that produces the same quality of food crops. Related to this, the writer has an idea to make the research about food crops. This research is based on Geographic Information System (GIS) which to find out location of food crop distribution in Java and Sumatera Island.

Based on (Budiyanto E., 2002) Geographic Information Systems (GIS) is a specialized information system to manage data that has spatial information (spatial referenced) or it is a computer system that has the ability to build, store, manage and show the geographic information for example, data identified based on its location, in a database. GIS can be explained into several subsystems as follows:

a) Data Input: This Sub-system is responsible for collecting, preparing, and storing spatial data and attributes from a variety of sources. This Sub-system is also responsible for converting or transforming the original data formats into a format that can be used by SIG software.

b) Data Output: This Sub-system is responsible to show or produce output (include exporting to the desired format). All of or part of database (spatial) both softcopy and hardcopy such as a table, graph reports, maps, and etc.

c) Data Management: This sub-system is well organized both spatial data and attribute tables related to database system, so it allows retrieving, updated, and edit.

d) Data Manipulation & Analysis: This Sub-system determined information that can be produced by GIS. In addition, this sub-system also performs manipulations (evaluation and usage of functions and mathematical and logical operators) and data modeling to produce the expected information.

According to (Z. Duran A, A. Garagon Doğru B., and G. Toz, 2003) the detailed GIS can operate with the following components.

a) The person performs the system such those who operate, develop and get benefit from the system. Categories of people who are part of the SIG variety, for example operators, analysts, programmers, database administrators and even stakeholders.

b) Application is procedure used to process data into information. For example, the sum, classification, rotation, geometry correction, query, overlay, buffer, and join table.

c) The data can be used in GIS, such as graphic data and attribute data.

d) Software is GIS software application that has the ability to program management, storage, processing, and analysis and show data spatial (eg *Arc View, Idrisi, ARC / INFO, ILWIS, MapInfo*).

e) Hardware is needed to run system in the form of computers, printer, scanner, digitizer, plotter and other supporting devices.

According to (Hosse and Schilcher, 2002) in agriculture, crops are all subjects of farm business that are not animals and cultivated in a space or a media which suitable for that business. This meaning can be distinguished from public use that the crops same with the plants. In fact, almost all crops are plants, but definition of plant covers several fungi (*mushroom foods, such as button mushrooms and studs mushroom*) and algae (*agar-producing* and *Nori*) deliberately cultivated for the benefit of economy. Crop *accidentally* planted, while the plant is something that appears or grows from the earth's surface.

Advanced research goal is to develop an application that has been designed to make distribution of food crops. This research-based Geographic Information System (GIS) to determine location of food crops distribution in the islands of Java and Sumatera.

2. Method and Design Applications

Application development is aimed at the development spread area of excellent food crop in Indonesia, which is on the island of Sumatera. Previous research only covers distribution of excellent crops across the province on the island of Java. Development was also conducted on the methodology of research such as creating *the Geographic Information System* of excellent crops distribution in Indonesia using *Google Maps* and *Fusion Database*. It also includes development of database structures for all provinces in Java and Sumatera. Mapping data is performed on the territory of which consists of several Region/Island. Each Region has some of the provinces.

The obtained data includes excellent crops data in all districts in Java and Sumatera which consists of plant Corn, Green Beans, Peanut, Soybean, Rice, sweet potato, and cassava. That data based on indicators of harvested area, production and productivity in 2008, 2009, and 2010. Table 1 is an example of data distribution of maize throughout the district in Banten province, which is one of the provinces on the island of Java.

Table 1: *Corn Data in Banten Province*

Regency	Harvested Area HA			Production TON			Productivity Ku/HA		
	2008	2009	2010	2008	2009	2010	2008	2009	2010
Pandeglang	2.042,00	3.219,00	2.694,00	0	10.348,00	8.836,0	0	32,15	32,8
Lebak	1.762,00	2.180,00	1.968,00	0	7.008,00	6.456,0	0	32,15	32,81
Tangerang	297	209	1.170,00	0	672	3.840,0	0	32,15	32,82
Serang	2.114,00	2.241,00	1.367,00	0	7.204,00	4.498,0	0	32,15	32,9
Tangerang	4	3	1	0	10	3	0	32,15	32,78
Cilegon	69	27	47	0	87	155	0	32,15	32,88
Serang	0	448	1.092,00	0	1.569,00	3.600,0	0	32,15	32,97
Tangerang Selatan	0	58	358	0	185	1.170,0	0	32,15	32,69

The usage of methodology in this research is development system using *Google Map technology* and *Fusion Database* which has ever been done by (Prahasta E., 2007). Figure 1 is workflow display of the method used. Frontend requested interface to the server which is received by SPARQL. Data is entered through *Tomcat servlet* matched and adjusted with *knowledge base* which available in *datasets* based on its ontology, and the result (*Ontology/Ontology Web Language/RDF*) transferred again into the server to be done *query* based on that Ontology.

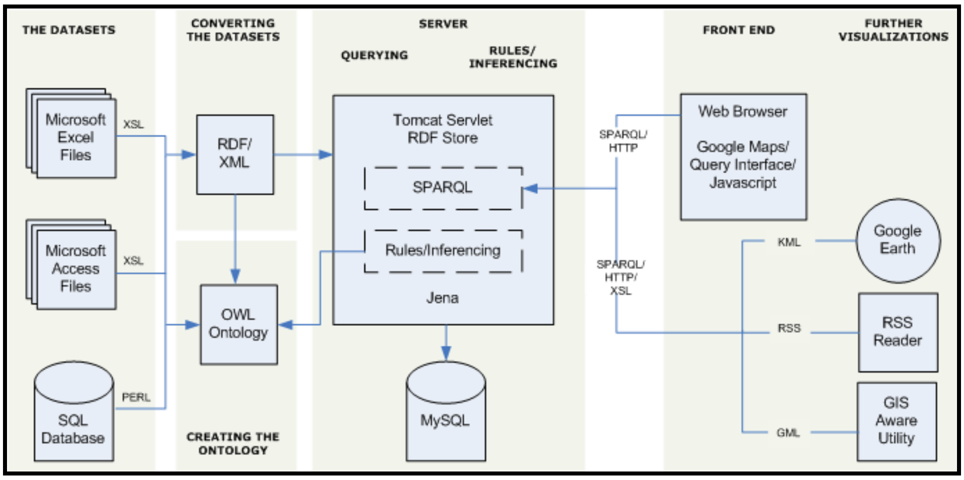

Figure 1: *Methodology of Database Connection and Google Map*

System development analysis has been done in this research which refers to (Mao J., R. Dutton, W. Chen, and W. Watson, 2008) in implementation of database is needed table structure design that can include the needs of system. Figure 2, table structure is used in the system includes the State Table, Table Region, Province Table, Regency Table, Plant Table, Table indicators, and Table Year along each attribute contained in the table.

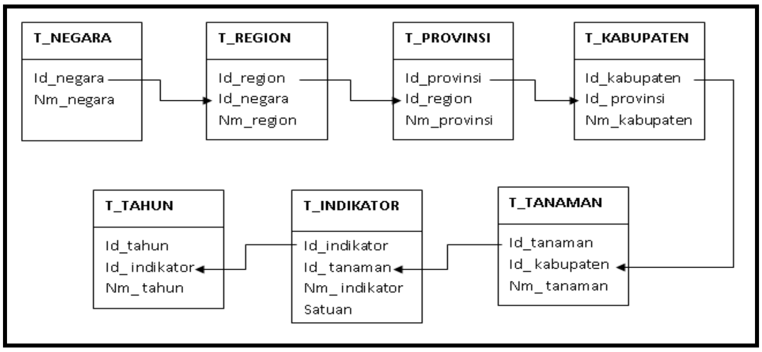

Figure 2: *Table Structure*

Development of database structure allows developers if there is the data changes such as addition, renewal, and or deletion of data on certain parts of it, then it will not affect the overall data structure. Here is an explanation of each table used in the system:

a. State table, this table shows location of country consisting of Id_State and Nm_State. Example of table 2 contains N01: country code, Indonesia.

Tabel 2: *State Table*

Id_state	Nm_state
N01	Indonesia

b. Region table, this table shows the region/island located in Indonesia country consisting of Id_region, Id_state, and Nm_region. Data region connected with id_state as the foreign key. Example of Table 3 contains of R 01 01: shows 01 the first is Indonesia, the second 01 is region/Java. R 01 02: shows 01 Indonesia, 02 Sumatera Island.

Table 3: *Region Table*

Id_region	Id_State	Nm_region
R0101	N01	Java island
R0102	N01	Sumatera island

c. Province table, this table shows all provinces in Java and Sumatera consisting of Id_province, Id_region, and Nm_province. Provincial data connected with Id_region as the foreign key. Example of Table 4 contains P 01 01: 01 shows the first is Indonesian, the second 01 is region/Java, and the last 01 is serial number of Banten. P 01 02 01: shows 01 state of Indonesia, 02 Sumatera Island, and 01 for serial number of Aceh Province and so on.

Table 4: *Province Table*

Id_province	Id_region	Nm_province
P010101	R0101	Banten
P010102	R0101	DI. Yogyakarta
P010201	R0101	Aceh
P010202	R0101	Bengkulu

d. Regency table, this table shows all districts in each province consisting of Id_Regency, Id_province, and Nm_Regency. Regency Data connected with Id_province as the foreign key. Example of Table 5 contains K 01 01 02 001: shows 01 the first is Indonesia, the second 01 is region/Java Island, 02 are DIY, and 001 is serial number of Bantul and so on.

Table 5: *Regency Table*

Id_Regency	Id_province	Nm_ Regency
K010102001	P010101	Bantul
K010102002	P010101	Gunung Kidul
K010201001	P010202	Aceh Barat
K010201002	P010202	Aceh Barat daya

e. Plant table, this table shows data on each plant consisting of Id_Plant, and Name_Plant. Example of Table 6 contains T01: Corn, T02: Green Beans plant.

Table 6: *Plant Table*

Id_plant	Nm_ Plant
T01	Corn
T02	Green beans
T03	Peanuts
T04	Soybean
T05	Rice
T06	Sweet potato
T07	Cassava

f. Indicators table, this table shows indicators on each plant consisting of Id_indicator, Nm_indicator, and Unit. Example of Table 7 contains I01: shows Area Harvested with the unit Hektor Are (Ha) and so on.

Table 7: *Indicator Table*

Id_indicator	Nm_indicator	Unit
I01	Harvested Area	HA
I02	Production	TON
I03	Productivity	Ku/HA

g. Year table, this table shows the usage of year. Example of Table 8 contains Y01: shows of 2008 related to the data obtained from Ministry of Republic Indonesia and so on.

Table 8: *Plant Table*

Id_Plant	Nm_ Plant
Y01	2008
Y02	2009
Y03	2010

h. Primary table is relation table between multiple tables above. At the primary table, there is *primary key* of each table, and new field is the value. *Field Value* can function to enter amount of agricultural data into database, as shown in Table 9. Table 9 consists of Id_primary, Id_state, Id_region, Id_province, Id_regency, Id_plants, Id_indicator, Id_year, and Value.

Table 9: *Primary Table*

Id_primary	Id_state	Id_region	Id_province	Id_regency	Id_plant	Id_indicator	Id_year	Value
U000001	N01	R0101	P010102	K010102001	T01	I01	Y01	65,94
U000002	N01	R0101	P010102	K010102002	T01	I01	Y02	64,11
U000003	N01	R0102	P010201	K010201001	T01	I01	Y01	169
U000004	N01	R0102	P010201	K010201002	T01	I01	Y03	43

3. Results

The following is display of interface design Web GIS *"Digitalization Application Development Crop-Based Geographic Information System (GIS) Commodity Featured in Java and Sumatera*".

(1) On the Web index page, there are 7 menus consisting of *Home, Profile, Maps, Tables, E-book, and About Us.*

Figure 3a: *Home Page*

(2) On the profile page, there is detailed explanation of function and performing of all the existing content on the Web GIS "*Digitalization Application Development Crop-Based Geographic Information System (GIS) Commodity Featured in Java and Sumatera*".

Figure 3b: *Profile Page*

(3) On the map page, there is standard view of Indonesia country. Accessible Island is Java and Sumatera. Additionally user can show data mapping across districts based on category indicators, Crop, Regional, and year which can be chosen in advance.

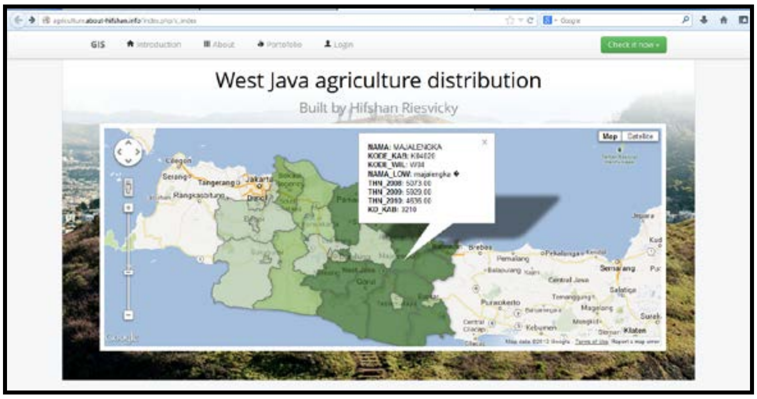

Figure 4: *Distribution Data of West Java Province using Google Map*

(4) On the Table page, it shows information data of each district in form of tables by category indicators, Plants, and area that can be selected in advance. Here is a sample table in Yogyakarta Province, with production indicators, in maize, in 2008, 2009, 2010.

Figure 5a: *Table Page*

(5) In Figure 5b, About Us page shows information about the design team within the Research Grants program titled "*Digitizing Crop-Based Geographic information System (GIS) at Local Commodities in Indonesia*".

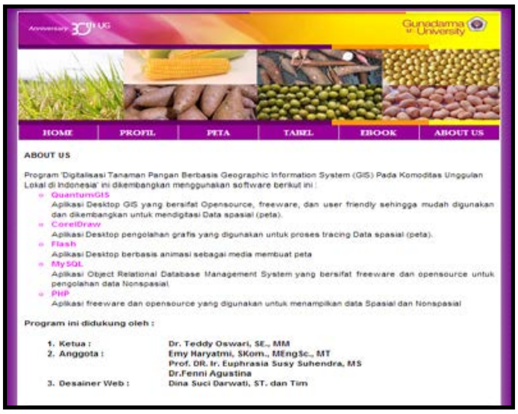

Figure 5b: *About Us Page*

(6) On *E-book* page shows information about excellent crops, such as corn, green beans, peanuts, soybeans, rice, sweet potato, and cassava. This information shows ranging from plants, how to grow crops, harvest time, to benefits for humans. (Constraints *e-book* exe file can't be displayed on the web, another alternative is to create a link so that users can download and access that *e-book*).

4. Conclusion

This application can be accessed by internet or mobile phone. This application was made to determine distribution of food plants in Java and Sumatera, then society can find out information about location which has the desired crops.

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Farmers' Perception of Erosion Risk and Its Implication on the Adoption of Soil and Water Conservation Practices

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Abstract Farmers' perception of the erosion risk relates with their decision to adopt its mitigation measures. Little has been done to escalate this idea as a basis for effective watershed management. This paper assesses farmers' perception of erosion risk; and examines the underlying factors guiding the decision for the choice of SWC practices. Interviews were conducted on 390 farmers in Nabajuzi watershed of the Lake Victoria Basin of Uganda. Data analysis was performed using a *Probit* regression model. The hypotheses tested were: (a) farmers' perception of the erosion risk does not correspond with their decision to adopt SWC practices; (b) the adoption level of soil and water conservation (SWC) practices is a reflection of both their technical performance and the degree of acceptability by local farmers. The perceived risk ranged sequentially from high to very high on geomorphic units of back slope, shoulder and summit; contradicting the USLE output whose range was moderate to very high. Farmers believed that management of these slopes should combine agronomic and structural measures. On the toe and valley, sheet wash was perceived to be a weak indicator of erosion risk; and if this form occurred, mulching was sufficient to contain it. The significant ($P<0.05$) factors in this watershed influencing farmers' adoption decision for SWC practices were: age, formal education level, on-farm income, family size, distance of farm from homestead, and access to agricultural extension service and training. It was concluded that though inconsistent with USLE, farmers' perception of the erosion risk was pivotal in adoption and implementation of SWC measures.
Keywords *Erosion Management, GIS, Lake Victoria Basin of Uganda*

1. Introduction

Mitigating the risk of erosion is a challenge to soil and water conservation (SWC) in smallholder farmer communities [27] particularly in Sub-Saharan Africa (SSA). For effective rehabilitation of the erosion affected landscapes, available pathways either emphasize landuse change; or adoption of appropriate SWC technologies. The latter is feasible since farmers are considered in the quest for SWC [34; 28]. Its adoption success, however, is a function of farmers' awareness and perception of the erosion risk [46]; which is said to vary over time and in space. Little information is available for bench-marking farmers' awareness and perception of the erosion risk in order to craft options for its containment [5]. In Uganda, the choice of appropriate land management technologies is rather difficult since land policies are not clearly defined [41]. As a result, most farmers in the rural setting are faced with insecure tenancy on the land; a factor that renders adoption of SWC technologies unattractive and unattainable [20].

At household level, success in erosion risk management attained if anchored on the degree of intensity of a farmer's prior knowledge of erosion risk on his/her agricultural land. This is the first stage in mitigating soil erosion [29]. The other stages following in tandem, being their interest in the decision to adopt, and their decision to determine the level of soil conservation practices to execute pertaining from previous perceived erosion risk.

However, there is no consensus on how perception of erosion risk is related to farmers' adoption of SWC practices. Additionally, conceptualization of the farmers' perception and erosion risk management is also a question of debate [16], for example, contended that this was a structural issue, encompassing socio-economic factors. Whereas this might be true, scanty information is available for heterogeneous landscapes about how on-farm profits derived from use of SWC technologies for reducing erosion risk could perpetuate additional usage of the said management practices. Some authors believe that this relationship between anticipated profits on-site and adoption of SWC practices is positive; while others that it is negative [30]. Mismatches are also identified in the factors that determine adoption of SWC practices in different spatial locations; of which [17] identified land ownership, tenure system and property rights on the land by farmers as the most critical ones.

Whereas [26] identified three critical issues in this debate such as perception of the risk itself, perception of the management strategies to avert the risk, and the socio-economic characteristics of the farmer, predicting these theoretical constructs based on empirical adoption models alone is an illusion [19]. Studies have therefore underscored the Theory of Planned Behaviour (TPB) or Reasoned Action Approach (RAA) for this purpose [35]. This is perhaps a more rational approach for erosion risk management at a wider scale [18]; a concept which requires further investigations. Assessing farmers' perception of the erosion risk is advantageous in SWC; it offers a balanced yard stick to judge the local farmers against scientific views in a bid to mitigate the erosion risk [46].

This study was, therefore, conceived based on TPB/RAA as shown in Figure 1, with the objective of assessing farmers' perception of erosion risk and examining farmers' decision for choosing erosion risk management practices at watershed level. We hypothesized that: (a) farmers' perception of erosion risk does not correspond with their decisions to adopt erosion management practices; (b) the adoption level of SWC practices is a reflection of both their technical performance and degree of acceptability by local farmers to increase agricultural production.

2. Materials and Methods

2.1. Site Description

The study was conducted in Nabajuzi watershed of the Lake Victoria Basin (LVB) of Uganda; located at latitude 0˚ 00′ 01″ N and 0˚ 20′ 01″ S, and longitude 31˚ 39′ 00″ and 31˚ 50′ 00″ E (Figure 2). This site is characterized by a high population density of 123 persons per Km^2 [45]; and high magnitudes of soil loss ranging from (25-140) t $ha^{-1}yr^{-1}$ [24].

Due to population pressure, inappropriate cultivation practices, deforestation and excessive grazing intensities, the soil of this watershed has been severely degraded, leading to a huge volume of pollutants into the basin [11]. Erratic and un-predictable rainfall regimes associated with high intensities [4] are received, a condition which is presumed to aggravate soil erosion risk in the watershed.

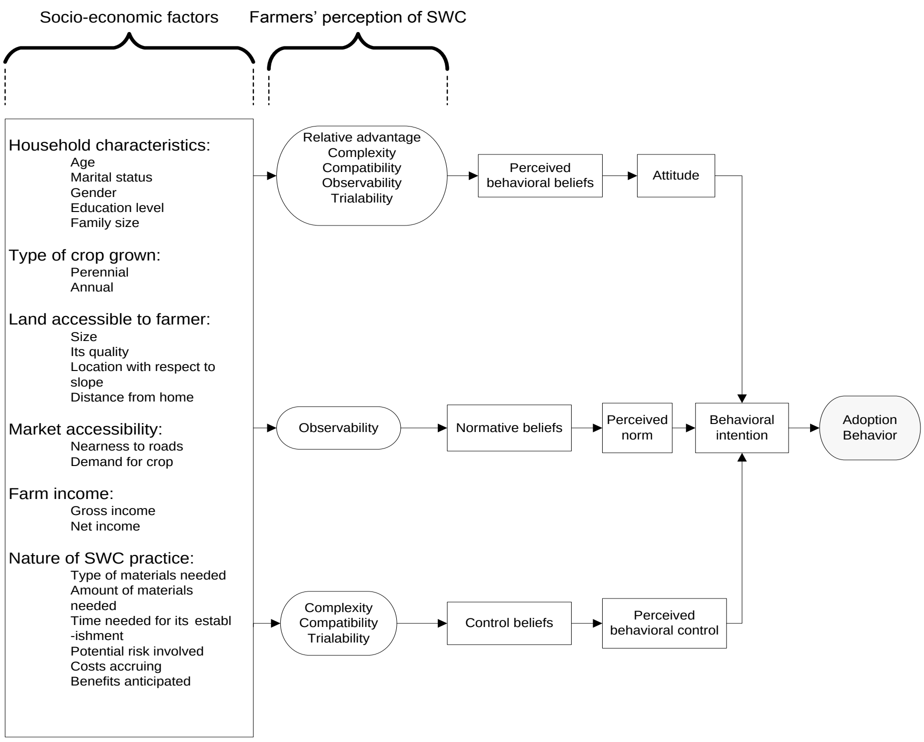

Figure 1: *Conceptualizing Farmers' Adoption of SWC Practices Based on the Perceived Risk of Erosion*

Source: Modified from Reimer *et al*., 2012

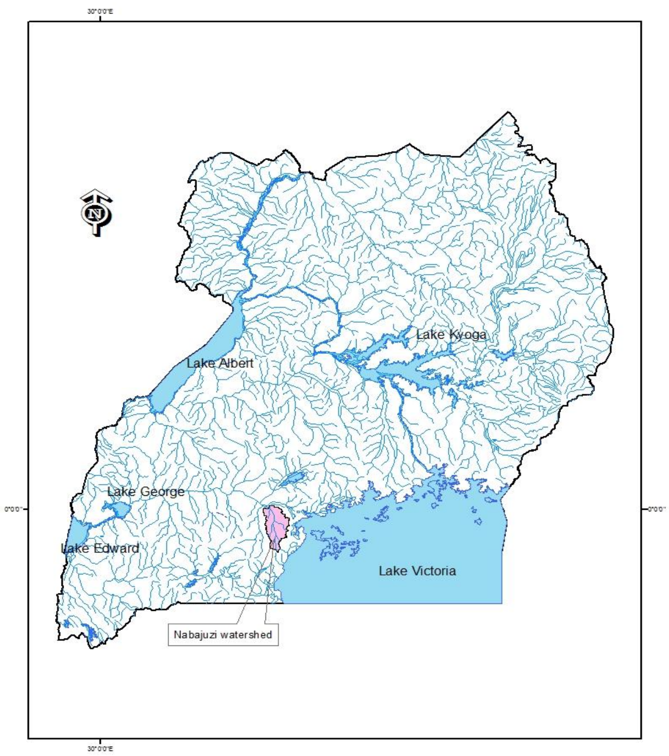

Figure 2: *Map of Uganda Showing the Location of Nabajuzi Watershed of the Lake Victoria Basin of Uganda*

2.2. Research Design and Survey Instrument

The study was conducted following a longitudinal design focusing on a particular farmer category in the watershed in order to obtain causal explanations about the erosion risk. A semi-structured questionnaire method was pre-tested and then used in a socio-economic survey.

2.3. Sample Size and Selection Procedure

The target population was the lowest income peasant farmers at household level who are most severed by the erosion effects. This target was achieved following poverty indicators generated by the Uganda Bureau of Standards [45]. There were 66 administrative parishes the watershed (Figure 3), and which were then overlaid with a household poverty shape file (to select number of households below the poverty line). A total of 24,000 households was obtained and this was regarded as population size (*N* = 24,000).

Sample size selection was based on the following procedure [3]:

$$n = \frac{pqN}{(SE)^2 N + pq} \qquad \text{(Equation 1)}$$

Where *n* = sample size,
N = population,
p = proportion of population possessing the major attribute (expressed as a decimal),
q = 1- *p*, and
SE = standard error of the proportion

Taking the confidence interval at +5% and confidence level at 95%, we derived the standard error of proportion as:

$$SE = \frac{5\%}{1.96} = 0.025 \qquad \text{(Equation 2)}$$

Therefore, our sample size (*n*) was determined as follows:

$n = \frac{0.5 \; X \; 0.5 \; X \; 24000}{(0.025)^2 \; X \; 24000 + 0.5 \; X \; 0.5}$ = 390 households, and these were interviewed during the survey.

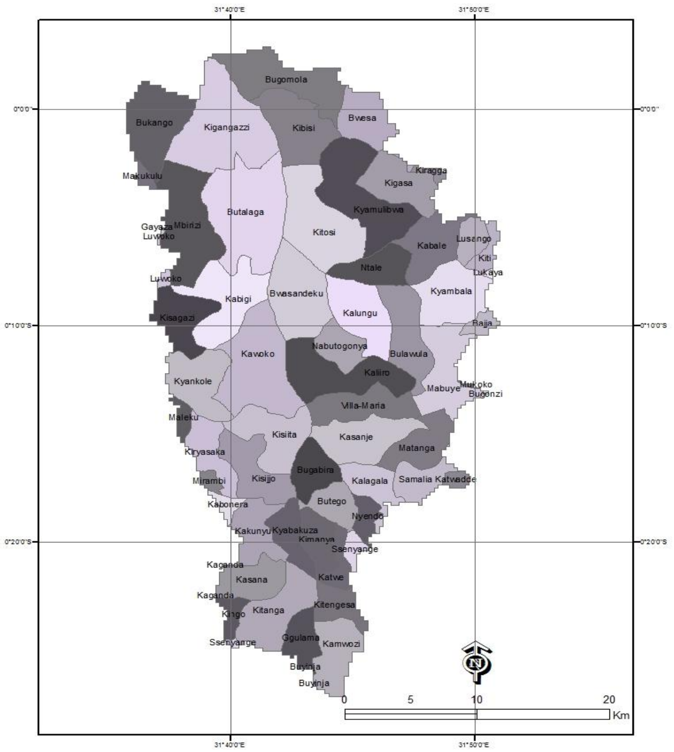

Figure 3: *Population (N) as Derived From Administrative Parishes in Nabajuzi Watershed in LVB of Uganda*

2.4. Variable Selection and Context

The independent variables were selected based on economic theories on adoption of SWC practices as established by [38]. On the other hand, the dependent variable was quantified based on a consultative meeting with twenty farmers, selecting four purposively from the five erosion risk classes (very low to very high) as in Figure 4.

The key informants were then involved in identifying what farmers considered as the most pertinent issue(s) with regard to erosion risk in Nabajuzi watershed. Using a binary indicator, farmers' awareness of the erosion risk was quantified. 80% of the key informants were aware of the occurrence soil erosion risk on their land parcels; while 20% were not. Hence, 16 farmers who were aware of the erosion risk were further engaged in selecting the dependent variable, which was quantified by an index. The magnitude of soil erosion risk and its possible causes in the entire watershed were then rated. A score of 3 was assigned for very much erosion risk; 2 for much erosion risk; 1 for moderate erosion risk; and 0 for low or negligible erosion risk. All these attributes carried the same weighting, to enhance quantification of farmers' perception of erosion risk. An arithmetic mean of the scores obtained from each indicator as shown in Table 1, with the highest mean being the most important variable.

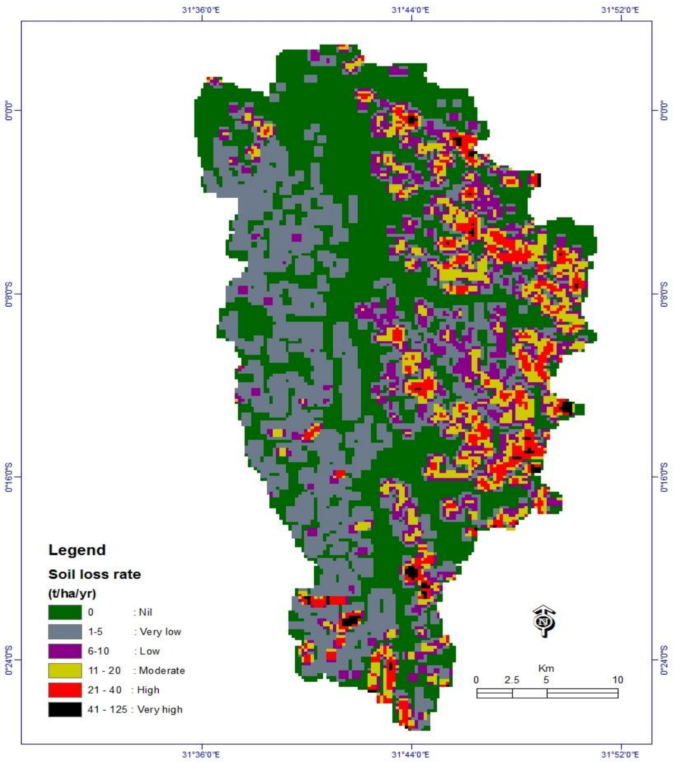

Figure 4: *Erosion Risk Potential for Nabajuzi Watershed of Uganda based on GIS-USLE modeling*

Table 1: *Scoring Farmers' Perception of the Erosion Problem in Nabajuzi Watershed in LVB of Uganda*

S/n	Indices	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	$\bar{X}$
										Scores								
1.	Erosion is very much in nearly all parts of watershed	3	2	3	1	0	3	3	2	3	2	3	2	1	2	3	3	2.125
2.	Erosion is much in some parts of watershed	2	3	1	2	1	2	2	3	2	3	2	0	2	3	2	2	2.000
3.	Erosion is moderate in all watershed area	1	1	1	2	3	1	0	1	0	1	1	3	3	2	1	1	1.375
4.	Erosion is low or negligible in all watershed area	0	0	0	2	2	0	1	0	1	0	0	1	0	1	0	0	0.5

F1…..16 = Farmer identification number as used in the scoring process; $\bar{X}$ = Arithmetic mean of the scores

Table 2 shows a summary of the selected variables, their definition, and measurement scale and how they affect farmers' adoption of SWC practices to reduce the erosion risk.

Table 2: *The Selected Variables and their Expected Effect on Adoption of SWC Practices*

Variable Name	Definition	Measurement	Unit	Expected Sign
(a) Dependent variable				
Farmers' awareness and perception of occurrence of the risk of erosion on their agricultural lands	Target all peasants in Nabajuzi watershed of the LVB of Uganda	scale	persons	
(b) Independent variables				
House-hold characteristics:				
- age of house head	chronological	scale	year	+
- marital status of house	yes or no	ordinal		+
head	male or female	ordinal	sex	+
- gender of house head	formal education	scale	year	+
- education of house head	persons one roof	scale	persons	+
- size of family under house	cohorts (child/adult)	scale	persons	+/-
head				
- age of family members				
Crop type:				
- perennial	crop value (food/cash)	categorical		+/-
- annual		categorical		+/-
Land accessible to a farmer:				
- size	quantity	scale	acre	-
- quality	productivity potential	categorical		+/-
- farm location	farm location versus slope			
- farm distance	position	categorical		-
	average distance from home	scale	metre	-
Market access	nearness of farm to roads and	scale	metre	+
	footpaths	categorical		
	available market demand for the crop			+/-
On-farm income	proxy indicator for farmers' ability to invest in SWC practices	scale	shilling	+/-
Nature of SWC practice				
- type and amount of materials	quantity	scale	acre	+/-
- risks and benefits of the SWC practice	anticipated	categorical		+/-

2.5. Farmers' Assessment of Erosion Risk

The method termed as '*Assessment of the Current Erosion Damage (ACED)*' was used to determine farmers' rating of the erosion risk. In this method, two activities were involved. The first was to conduct a transect walk with the previously selected key farmers. While, the second activity was to select and quantify with farmers the erosion risk of indicators on different slope positions.

During field excursion, erosion indicators were observed from plots of 30 m by 30 m; a dimension that was considered sufficient enough for rills to develop [23]. These plots were purposively selected and mapped with a hand-held Global Positioning System (GPS) receiver on to the erosion risk map, previously generated using GIS-based USLE model for the site (Figure 4). Farmers' perception of soil erosion risk was matched with the erosion classes identified in Nabajuzi watershed. This formed a platform for validating the results and quantifying the erosion risk indicators, since they form a foundation for proper SWC formulation [29].

Whereas their classification is usually based on current and past erosion features, this study focused on erosion processes; soil- and crop-related features to determine farmers' rating of the erosion risk. The considered alternatives for each criterion were its severity; most critically affected landuse; slope angle and topographic location within the watershed (Figure 5).

The strength ($P_{ij} \geq 0.7$) and weakness ($P_{ij} \leq 0.7$) of these indicators were then statistically established [46] as presented in Equation 3.

$$P_{ij} = 1 - \frac{\sum_{0}^{j-1} n_{ij}}{n_i}$$ ……………………………………(Equation 3)

Where: *Pij* is the probability that an indicator, *i* occurred in an erosion class equal or greater than *j*;
n_{ij} is the number of presence of an indicator, *i* appearing in an erosion class *j*; and
n_i is the total number of presences observed for indicator *i.*

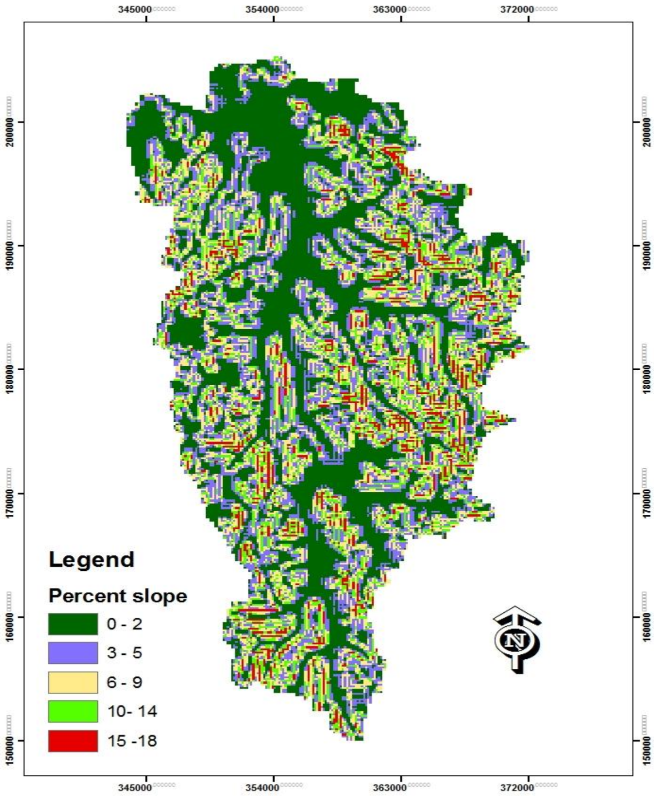

Figure 5: *Percent Slope Categorization to Quantify Farmers' Perception of Erosion Risk in Nabajuzi Watershed*

2.6. Farmers' Adoption Level of SWC Practices

Literature highlights methodological constructs relating the level of adoption for soil conservation practices [13; 34]. A critical concern is that there is no consensus among these constructs. This study embraced the idea of estimating the farmland area under conservation practice as an indicator of farmers' adoption level [15]. Therefore, the field plots (30 m by 30 m) already established during transect walk were used for this purpose. The plots were divided into equal quadrants (15 m by 15 m) such that the proportion of the area under SWC was estimated by direct observation; and the dominant practices were recorded. Individual farmers' perception and awareness for soil erosion risk was assumed to have binary outcomes. The *Probit* regression model was used to quantitatively identify factors that influence the adoption of SWC practices. The general form and identified variables for this regression model are presented in Equation (4).

$Y = \beta + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 +$ ……………… $+ \beta_{12} X_{12} + e$ ……………………(Equation 4)

Where: $\beta_1 \ldots\ldots \beta_{12}$ = coefficients to be estimated by the regression model;

e = random error term;
Y = farmers' perception and awareness of the erosion problem;
X_1 = age of house head (*in years*);
X_2 = family size (*excluding* extended family members);
X_3 = education level of house head (*in years of schooling*);
X_4 = marital status of house head;
X_5 = distance to the garden from home (*in metres*);
X_6 = land size (*in acres*);
X_7 = total spending in SWC as a proxy for income of house head;
X_8 = land quality of the parcel;
X_9 = length of time for accessing the land parcel (*in years*);
X_{10} = farmers' access to agricultural training and extension services;
X_{11} = land tenure and ownership system operating in the watershed;
X_{12} = crop type grown.

2.7. Statistical Analysis

The data were entered in Statistical Package for Social Sciences (SPSS) version 16 and transferred to STATA for easy analysis. The outliers, normality (distribution) and symmetry (skewness and kurtosis) were all checked using explanatory data analytical procedure. The identified outliers were discarded; and since the data were found to be normally distributed with no skewness or kurtosis, further analysis was guaranteed. Multi-collinearity was also tested using Variance Inflation Factors (VIFs) and a covariance matrix. The covariance matrix showed no Multi-collinearity in the data. Similarly, all variables showed VIF values which were less than 10, a condition which proved that the degree of linear relationship among variables was fine. Therefore, all the selected variables were used in the running of the *Probit* regression model (Equation 4).

3. Results and Discussion

3.1. Farmers' Perception of Erosion Risk *versus* GIS-Based USLE Prediction

Results showing a comparative assessment of farmers' perception the erosion risk with the USLE prediction output are presented in Table 3. A variation was evident between farmers' belief about soil erosion risk and what is predicted by USLE. Mismatches were recognized in processes, rates and magnitude in relation to topographic positions which are known to farmers, as opposed to what the model predicts. Sometimes farmers' perceived erosion risk indicators were not actually important in this watershed (*$P<0.7$*). For instance, whereas farmers recognized sheet wash as a low erosion risk indicator, it was also a weak one. The area they associated with such a risk, was potentially low-lying (valley & toe slope); hence, susceptible to deposition processes rather than to erosion processes. But within the same area, the USLE predicted erosion risk to 0-10 t $ha^{-1}yr^{-1}$. This is a substantial quantity of soil loss which calls for mitigation attention since it is above the tolerance level of 5 t $ha^{-1}yr^{-1}$ [43]. Most farmers perceived soil stoniness to bear a high erosion risk, an observation which was in line with USLE prediction (21-40 t $ha^{-1}yr^{-1}$). Unfortunately, soil stoniness in this analysis was regarded as a weak erosion risk indicator, a condition which could be attributed to thin and/or young soil profile. Finally, farmers perceived poor seed germination and poor crop development as a moderate risk of soil erosion, which was now in line with what the USLE predicts. But all these indicators were weak, since such conditions could be associated with either low soil fertility or pest and diseases damage rather than to soil erosion risk.

By and large, the strong erosion risk indicators (*P>0.7*) identified in the survey were interrills, rills, gully development, presence of some bare patches of rocks, absence of top soil layer, presence of pedestals, exposure of crop roots, washing and bending of crops. Distinguishing the indicators as discussed above, was a plausible means of harmonizing farmers' perception of erosion risk with scientific knowledge to provide a rational strategy for adopting SWC practices at a watershed scale.

Table 3: *Farmers Assessment of the Erosion Risk in Nabajuzi Watershed of the LVB of Uganda*

Identification Criteria	The most observable erosion indicator(s) in the estimated plots	Strength/weakness of the erosion indicator (s) in the plots using (Equation 3)	Farmers' erosion risk perception	Farmers' estimation of the most affected crop cover	Geomorphic slope description along the transect line	Slope gradient (%)	Erosion risk according to a GIS-based USLE model (t ha^{-1}yr^{-1})
Process	Sheet wash	0.4	Low	Horticulture	Valley and toe	0-5	0-10
	Interrills	0.8	High	Horticulture	Back slope	6-9	11-20
	Rills	0.7	High	Banana	Shoulder	10-14	21-40
	Gully development	0.7	Very high	Banana	Shoulder	10-14	21-40
Soil Features	Soil stoniness	0.6	High	Banana	Shoulder	10-14	21-40
	Presence of some patches of bare rocks	0.7	High	Banana-coffee	Summit	15-18	41-125
	Absence of top soil layer	0.8	Very high	Banana-coffee	Summit	15-18	41-125
	Presence of pedestals	0.7	Moderate	Horticulture	Back slope	6-9	11-20
Crop Features	Exposure of roots	0.7	Very high	Coffee	Back slope	6-9	11-20
	Poor seed germination	0.4	Moderate	Cereal crops	Back slope	6-9	11-20
	Washing of crops	0.8	High	Cereal crops	Back slope	6-9	11-20
	Bending of crops	0.7	Very high	Banana	Back slope	6-9	11-20
	Poor crop development	0.4	High	Banana	Back slope	6-9	11-20

3.2. Empirical Analysis and Variables

Table 4 presents results obtained from the *Probit* regression analysis. The most significant factors influencing farmers' decisions to adopt SWC practices to mitigate the erosion risk are consequently discussed in the subsequent sections.

Number of observations = 390
LR chi^2 (10) = 78.76
Prob > chi^2 = 0.0000
Log likelihood = -100.11821
Pseudo R^2 = 0.2823

Table 4: *Results of the Probit Regression Analysis*

Awareness_percep	Coef.	Std. Err	z	P>|z|	[95% Conf. interval]	
Age	-.645777	.3072047	-2.10	0.036**	-1.247887	-.0436669
Farmer income	.6800275	.280724	2.42	0.015**	.1298185	1.230236
Family size	.2707459	.0793255	3.41	0.001***	.1152707	.426221
Farm distance	.5960017	.2119934	2.81	0.005**	.1805024	1.011501
Education	.1772243	.0388721	4.56	0.001***	.1010363	.2534123
Farmer training	.0238471	.0140307	1.70	0.089*	-.0036526	.0513468
_cons	-2.854128	.7734741	-3.69	0.000	-4.37011	-1.338147

* Significant at P ≤ 0.1; ** Significant at P ≤ 0.05; *** Significant at P ≤ 0.01

Where: Coef. stands for a coeffient determining the change in independent variables on the dependent one; Std. Err for standard error; z for Z-score; P for Probability; Conf. for confidence interval; and cons for constants which would equal to the dependent variable if all the independent ones were equal to zero.

3.2.1. Age of Household Heads

The age of household head was negatively related with adoption of SWC practices (r = -0.646, Table 4); implying that the younger the household head the more likely that s/he adopts SWC practices. The underlying reason is that young farmers may still have a long span of time to plan for their lives than the old ones who may be highly vulnerable to life threatening risks. Besides, young household heads are usually more educated, physically fit and highly adaptive to new innovations with regard to SWC technologies. Empirical studies [15; 38] also had a similar observation, showing that the age of the farmer was negatively correlated with adoption of SWC practices. As farmers become older, they become weaker; and implementing SWC practices is rather challenging even when they are aware of the erosion risk [22]. In the study site, we recognized that farm labour was provided by household members whose physical strength would easily be compromised by old age. This argument is supported by [6] on the basis of a Multinomial *Probit* regression analysis and differential calculus; observing that the maximum age of a farmer to adopt SWC practices would approximately be 51 years. In the study site, the average age of the respondents was 43 years, an age below the calculated age-limit for adoption potential. This age (43 years) suggests that the farmers in this watershed would adopt new SWC technologies to reduce the risk of soil erosion.

3.2.2. Economic Significance/Profitability

The relationship between farm income and adoption of SWC practices in this site was positive (r = 0.68, Table 4). This was in line with an earlier study by [1]. The SWC technologies that are usually perceived to be profitable are usually adopted by farmers [10]. Therefore, the result obtained on this relationship was indicative that the more the farmers realized high potential income from such management practices, the more they would adopt them. The long term implication of SWC is contrary to this. As SWC practices become more and more beneficial strategies for land management, farmers tend to disregard them since they will have already acquired enough income to start other business enterprises [25]. Premised on this, studies have shown that off-farm income plays an unattractive role in influencing farmers' decision to adopt SWC practices [21]. Whereas [38] found a negative relationship caused by off-farm income on adoption of SWC practices, [37] recognized a positive one. Off-farm income activities tend to reduce the economic significance of the erosion problem because of the less time, less labour and less interest that farmers will have for installing new and maintaining the existing SWC practices [39]. Thus, farm income of great significance to adoption of SWC practices is on-farm [2]. Off-farm income was out of scope in this study; but further economic investigation is needed to establish quantitatively the equilibrium level for farm-income to impact farmers' adoption for SWC practices.

3.2.3. Education Level

The level of education attained by a farmer was a positive significant factor (r = 0.177, Table 4). This supports what was previously noted by empirical studies on the same variable [12]. Education influences the level of awareness; hence farmers perceive the occurrence of soil erosion risk on their land parcels. Whereas this is true, the effect of education on the adoption of SWC practices is ambiguous. For instance, some studies show that increasing the education level increases the farmers' likelihood to adopt SWC practices; which consequently reduce soil loss [33]. On the other hand, increasing the education level increases the opportunity cost of the labour; which negatively affects the adoption of labour-intensive SWC practices.

3.2.4. Family Size

This study revealed rather controversial results relating to family size in Nabajuzi watershed (Table 4). A positive coefficient was noted implying that the larger the family size, the more likely that the members would adopt SWC practices. This can be attributed to the fact majority of the farmers in this watershed (75%) had no off-farm income generating activities. Thus, to ensure continued food supply to sustain their livelihoods in the area, the only option was to rudimentarily adopt some SWC practices. This was in line with an earlier view which was advocated for by [40] in Kenya. Secondly, a large family was advantageous in establishing physical structures for erosion management since much of the labour force in this watershed was easily provided by family members. This variable has been variously reported by some empirical studies [38; 8] to have a negative effect on farmers' adoption behavior for SWC practices. This situation implies that the larger the family size, the less the member would be interested in investing in SWC practices. Earlier studies suggest that as large families face food shortages due to drought, they tend to maximize short-term seasonal benefits rather than paying attention to SWC practices which benefit them in long-run. Perceived risk of erosion missing

3.2.5. Household Location

In Nabajuzi watershed, the commercially-oriented crops whose benefits were realized in short-run, generally received maximum attention and supervision regardless of the distance between a farmer's home and the farm (Table 4). Such crops included tomatoes, onions and cabbages that were grown on well-managed plots located on the toe slopes and valleys far away from farmers' homes. But for other crops such as banana and coffee, the observation was quite different from the one above. Banana plantations that were within a radius of less than 100 m around the homesteads were intensively managed as opposed to coffee. Priority to banana was attributed to its being a staple food while coffee which was traditional cash whose benefits to the farmers were not immediately achieved. Descriptive statistics showed that the average distance of the farms from homesteads was a 430 m. This condition resulted into contradictory findings than those in literature; and indicated a positive relationship with respect to adoption of SWC practices in this watershed. This implies that the longer the distance from home the farm was, the more the farmers would adopt SWC practices. This unusual observation was attributed to the ambiguous impacts of commodity prices on adoption of SWC practices which were earlier noted by [32]. For instance, the higher the commodity price, the more incentives would land users obtain, hence; adopting SWC practices for continued profitability of the landuse. Unfortunately, high commodity prices could also trigger encroachment into the fragile and marginal lands in a bid to increase agricultural production, hence; leading to further soil erosion risk. Such linkages require further investigation particularly at a watershed scale. Previously, studies indicated that longer distances discourage investments in SWC practices due to additional costs accruing from transport [14]. Thus, farms located near homes are believed to receive maximum attention and supervision [7].

3.2.6. Level of Training

Farmers who received better agricultural training and other extension services were more likely to adopt SWC practices in Nabajuzi watershed (Table 4); and the reverse was also true as shown by the positive correlation coefficient value obtained for this factor. Most importantly, was the fact that access to such services was easily attained by large families as opposed to smaller ones; and this increases their exposure to better agricultural innovations [43]. This in turn, influences their adoption behaviour for SWC practices to reduce the risk of soil erosion [7].

3.3. Adoption Intensity of SWC Practices

Results indicating farmers' adoption intensity for SWC practices are presented in the Figure 6. The SWC practices commonly used in this watershed were agronomic with contour bunds, mulches and trash lines being the most dominant ones.

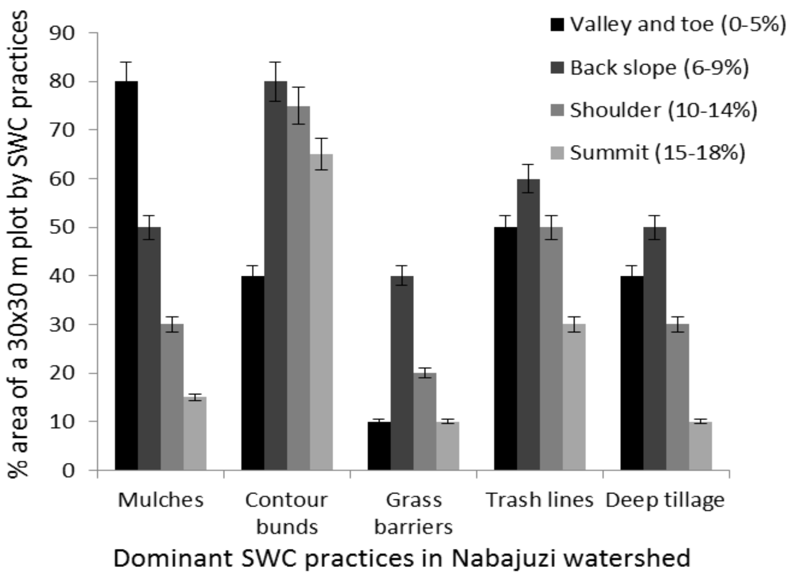

Figure 6: *Intensity of Farmers' Adoption for SWC Practices in Nabajuzi Watershed in LVB of Uganda*

The adoption intensity of these SWC practices was in resonance with the perceived severity of the erosion risk. Farmers constructed contour bunds in a *fanya-chini* design mainly to improve runoff retention and reduce soil losses across slope gradients of the perceived geomorphic units with a severe risk of erosion. Since the efficiency of contour bunds depends on infiltration capacity of the soil [42], farmers adopted other SWC practices such as grass barrier strips, trash lines and deep tillage to supplement the bunds for this purpose. On the other hand, mulching was emphasized based on it known potential for reducing surface sealing, improving water holding capacity as well as micro-organisms' activities in the soil. Therefore farmers believed that these conditions could help in reducing soil erosion risk particularly on level to gently undulating slopes (0-9) %. However, for steeper slopes, farmers held the view that structural erosion risk management measures were important for supplementing the agronomic and vegetative practices in reducing runoff and soil losses from agricultural land.

4. Conclusion

The risk of soil erosion was perceived to be severe on back slope, shoulder and summit; hence, in a farmer's view such risk could be reduced by integrating agronomic and structural measures at such geomorphic units as deduced from the level of willingness to adopt such SWC practices. Further perception of the farmers was that mulches could be applied in sheet wash areas in the watershed. Lastly, the level of adoption for SWC practices was influenced by age of farmer, education level, on-farm income, family size, distance of farm from homestead, and access to agricultural training and other extension services. Therefore, the strategy of coupling of farmers' perceived risk of erosion with USLE model outputs is one of the most viable ventures for proper erosion management and rehabilitation of the degraded agricultural watersheds. This increases the farmers' willingness to accept and sustain new SWC technologies targeting such agricultural lands.

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