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EDITORIAL

On behalf of the scientific editorial board, I wish to extend my deepest gratitude to the great contribution made by lecturers and researchers that has made the compilation of this publication a success. The completion of this volume was a result of their will, initiative and performance as lecturers and researchers. KIGALI INDEPENDENT UNIVERSITY ULK has always paid regards to promoting education and impacting the complete development of Rwanda through coupling teaching and research. In this spirit, the 45th Volume of the ULK Scientific Journal is now out with four papers which tackle issues of national and regional concern. The authors of articles in this issue suggest scores of recommendations worthy of consideration to both policy makers and practitioners.

The first article by **Dr. HABIMANA Olivier, Dr. KABANDANA Innocent** and **Dr. UWITONZE Alfred** is entitled “**Convolutional with Attention Gated Recurrent Network for Sentiment Analysis.**” In this publication, the authors put it that the multiple convolutional applied helps the model extract possible local features by retaining the order of words in the input sentence; and that the Bi-GRU learns global features.

The article by **Dr. KABANDANA Innocent** and **Dr. UWITONZE Alfred** is dubbed “**Electronic voting system via GSM**”. The authors recommended that the Electoral Commission

of Voting System should train the key persons who will be monitoring electoral activities from the beginning to the end.

The paper by **Mr. AMANI MANZI Alain** reads “**An Evaluation of Financial Literacy among Business Owners of Micro, Small and Medium Enterprises in Rwanda**”, focused on evaluating financial literacy among micro, small and medium business owners in Rwanda. Besides, the measurement of financial literacy levels relied on the use of financial knowledge, financial skill, attitude towards financial matters and financial behavior.

The article that tops the list of publications in this Volume is authored by **MFITIRYAYO Jean de Dieu** and it is entitled, “**Replication of success for sustainable rural livelihood development with inclusive innovation in Rwanda: A case of neighboring communities in Ngeruka Sector**” The author argues that the study has shown the worth of replication of outcomes among communities. This approach has helped the communities to help themselves and reduce reliance on external funding or to remain a burden on the government.

Dr. RUSIBANA Claude, PhD

Vice Chancellor of ULK

**CONVOLUTIONAL WITH
ATTENTION GATED RECURRENT
NETWORK FOR SENTIMENT
ANALYSIS**

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ABSTRACT

In recent years, deep learning approaches like convolutional neural networks (CNNs) and recurrent neural networks (RNNs) have received much attention to natural language processing tasks, especially to sentiment analysis. Different methods will be used to measure the Convolutional with Attention Gated Recurrent Network for Sentiment Analysis. Thankfully, these methods achieved significant results. However, these approaches individually fail to accomplish the task of sentiment analysis at the extent level. In sentiment analysis, the likelihood of a given word is estimated based on long-term dependencies and local contextual features that depend on a word and its neighboring words. This paper suggests a Convolutional with Attention Gated Recurrent Network (CAGRNN) model performs the sentiment analysis by extracting these features. The objective behind our model is to apply the CNN layer to extract local contextual features. Afterward, the CAGRNN uses a bidirectional gated recurrent unit (Bi-GRU) layer to encode the long-term dependence features. On the other hand, the attention mechanism is applied to help our model select the convenient words that hold sentiment information. The CAGRNN performs better in sentiment

analysis by using the learned features. Our approach achieves competitive results on two real datasets IMDB and SSTb, compared with baseline models and requires fewer parameters. Executing various ablation experiments of our model components will be done in future.

Key findings: Convolutional Neural Networks (CNNs);
Recurrent Neural Networks (RNNs); Convolutional with
Attention Gated Recurrent Network (CAGRNN)

1 Introduction

Web 2.0 applications, such as online social networking and e-commerce websites, have exploded in popularity recently, allowing participants to freely share their ideas and opinions in a text (Pang & Lee, 2005; Pozzi et al., 2017). Sentiment analysis is a natural language processing task that looks for opinions expressed in user-generated content (UGC). Discovering hidden knowledge from user-generated content (UGC) is priceless (Liu, 2012; Pang & Lee, 2008) to individual-level up to big organizations and governments. An individual user can decide to buy a product by judging other customers' comments who have purchased that product. By analyzing customers' reviews, e-commerce companies can improve

their service delivery. Government organizations can take different measures based on the understanding of the public opinions about any trending topic. Additionally, sentiment analysis can improve the capability of recommender systems by identifying the aspects that the user wants (Poria et al., 2016; Z. Wang & Zhang, 2017).

So far, numerous approaches for sentiment analysis have been proposed in the literature (Liu, 2012; Pozzi et al., 2017; L. Zhang et al., 2018). The designed approaches extract and apply important features in sentiment analysis. However, the suggested approaches perform the sentiment analysis by relying on the general features extracted from the input embeddings. This is certainly helpful, but it is not always a perfect solution in sentiment analysis. In practice, it is more important to perform the sentiment analysis by using all the contextual features of the word in a sentence, which we refer to as contextual sentiment analysis in this work.

Generally, in sentiment analysis, the likelihood of a given the word is estimated based on features that depend on a word and its neighboring words (Mousa & Schuller, 2017; Muhammad et al., 2016; Wilson et al., 2005). In this work, we focus on two important categories of features. The first category includes local contextual elements heavily influenced by the arrangement of words in a phrase. Actually, the order is important because the polarity of a

word in a sentence can change based on where it is in the sentence. Long-term dependencies are the second sort of feature that can exist in a sentence. Therefore, we claim that modeling these contextual features is of great value.

A natural method to solving the challenge of sentiment analysis is to use classic sentiment analysis approaches based on lexicons (Taboada et al., 2011), n-gram, and part-of-speech tags (POS) (Bespalov et al., 2011; Pang et al., 2002). Bag-of-words (BoW) (S. Wang & Manning, 2012) approaches can also be applied. However, the performance of these approaches in sentiment analysis is often unsatisfactory due to the following reasons. First, the performance of these approaches relies on tedious feature engineering work. Second, concerning lexicon-based approaches, the context sentiment of a givenword can be different from the prior polarity of that word in the lexicon (Muhammad et al., 2016). Third, the n-gram based models are accused of suffering from data sparseness. Lastly, BoW based approaches handle the input texts as unordered sets of words. Thus, they cannot model the necessary information and syntactic features for sentiment analysis

Furthermore, deep learning methods can be used to address the problem of contextual sentiment analysis. In recent years, thankfully, these approaches have improved the results considerably

in sentiment analysis due to the capability of automatic feature learning with a hierarchy of layers (Deng & Yu, 2013). Also, their success is attributed to the success of word embedding models that allow the distributed representation of words (Mikolov et al., 2013; Pennington et al., 2014). Deep learning models like convolutional neural networks (CNNs) (Collobert & Weston, 2008) and recurrent neural networks (RNNs) like long short term memory (LSTM) (Hochreiter & Schmidhuber, 1997) and gated recurrent unit (GRU) (Cho et al., 2014) achieved tremendous success in sentiment analysis compared to other models. Consequently, numerous approaches have been proposed in the literature.

Researchers have suggested a plethora of CNNs based models for sentiment analysis; Kim (2014) used a multi-channel CNN for capturing multiple features in the local context. Very deep CNNs, on the other hand, have been investigated for capturing long-range relationships (Conneau et al., 2017; Johnson & Zhang, 2017). Also, Johnson & Zhang (2014) applied a CNN-based model for the best use of word order to represent the text. Similarly, Kalchbrenner et al. (2014) investigated the use of dynamic CNN to learn the semantic features of a sentence. However, the proposed CNN-based models are a partial solution to the contextual sentiment analysis because CNN can only exploit the local features. In addition,

capturing long-range dependencies requires the CNN to be deeper; hence, expensive computational resources are required.

On the other hand, RNN based models proved to be efficient in learning the sequence inputs and modeling long-range dependencies to maintain the constant error flow (Mujika et al., 2017). As a result, to deal with the context in which the term appears, Lin et al. (2018) applied the structure-attention LSTM, Mousa & Schuller (2017) explored the use of a Bi-LSTM. Similarly, M. Zhang et al. (2016) suggested a gated RNN. Moreover, RNNs have been applied for capturing long-range dependencies, Yang et al. (2017) applied an LSTM. Similarly, Mujika et al. (2017) applied a Fast-Slow RNN. Likewise, N. Wang et al.(2017)suggested a Bi-GRU with attention, and also Chen et al.(2017) applied a multiple attention LSTM. Although these models produced interesting results, their behavior to sentiment analysis is still unsatisfactory. Their unsatisfactory performance is associated with the RNNs model the sentence in temporal order, i.e., the output depends on the previous context. In addition, RNNs do not preserve the structure of the input sequence. Furthermore, RNNs are biased in terms of the representation where the words at the beginning of the sentence are less considered than those at the end of the sentence. Thus, the RNN does not model the semantic information as it can appear anywhere in the sentence.

Therefore, a question raises to our mind: “How can we design a computationally less expensive model suitable for contextual sentiment analysis. A model that uses the contextual information at an extent level in that the order of the inputs is preserved; the local and semantic features are exploited; and the global features are captured”.

To this end, motivated by the above findings, we suggested an approach called Convolutional Attention Gated Recurrent Network (CAGRNN) to answer the above question. The CAGRNN combines the CNN with Bidirectional-GRU (Bi-GRU) with an attention mechanism based. The CAGRNN inherits the characteristics of CNN for preserving the spatial structure of the input sequence by using the one-dimensional structure of the text data (Johnson and Zhang, 2014), good local feature detectors, i.e., filters that capture n-gram at every position of the sentence and using few parameters that help speed up the training process. To avoid the deeper network, our model follows the multi-channel CNN model (Kim, 2014), which is shallow and wide. To model the input sentence in sequential order and capture the global features like long-term dependencies, we use the Bi-GRU that processes the input sentence forward and backward. Finally, we utilize the attention mechanism extensively applied in neural translation machines (Bahdanau et al., 2015;

Luong et al., 2015) to allow our model to prioritize the words containing the sentiment at any location in the sentence.

Overall, the main contributions of this paper are three-fold:

- We propose a combined approach CAGRNe that enhances the performance of CNN with Bi-GRU coupled with an attention mechanism for sentiment analysis. To our knowledge, this is the first work to combine all these three models.
- The attention mechanism is proved to increase the model's performance to realize the sentiment analysis by capturing the words responsible for sentiment at any position in the sentence.
- We conduct comprehensive experiments on IMDB and SSTb datasets. Our model CAGRNe outperformed state-of-the-art models with a few parameters.

The remainder of the paper is structured as follows. Section II discusses the related work to our sentiment analysis model. A detailed description of CAGRNe architecture is provided in Section III. The experiment setup and results are described in Section IV. Finally, section V concludes the paper with a final remark.

2 Related Work

A large number of researchers have been interested in sentiment analysis. As a result, a variety of ways have been offered. In sentiment analysis, deep learning algorithms such as CNNs and RNNs and their modifications have shown superior outcomes. CNN, Bi-GRU, and the attention model are all used in our research. Therefore, this section discusses different proposed models related to our work.

2.1 Convolutional Neural Networks

A large number of CNNs based models have been proposed for sentiment analysis; Kim (2014) used a multi-channel CNN trained on top word2vec pre-trained word embedding. Y. Zhang et al. (2017) conducted the sensitivity analysis of CNN models to prove the effect of CNN architecture on the performance. The study (Xu et al., 2017) applied a deep CNN for multilingual sentiment analysis. Conneau et al. (2017) investigated the effectiveness of deeper CNN to deal with the long-range association of the sentence. Similarly, Johnson & Zhang (2017) applied deep pyramid CNN for capturing long-range dependencies. Also, Johnson & Zhang (2014) also utilized a CNN-based model for the best use of word order in the text representation. Kalchbrenner et al. (2014) used a

CNN-based model network that handles varying length input sentences and captures short and long-range dependencies. Santos & Gatti (2014) proposed a deep CNN that exploits character-to-sentence-level features and detects negation. The study by X. Zhang et al. (2015) designed a CNN that proves the usefulness of character information in text classification.

2.2 Recurrent Neural Networks

Many RNN-based approaches have been proposed in the literature to learn sequence inputs and represent long-range dependencies. Similarly, Lin et al. (2018) applied the structure-attention LSTM to model the contextual information. Also, Mousa & Schuller (2017) explored a generative contextual Bi-LSTM to learn each word's right and left context in the sentence. Likewise, a gated RNN model was proposed by M. Zhang et al. (2016) to capture semantic and syntactic information as well as represent the context in which a word appears. Long-range dependencies, on the other hand, have been captured using RNNs. Yang et al. (2017) developed an LSTM model to deal with a long input sentence and a target aspect discriminative features.

Meanwhile, Mujika et al. (2017) applied a Fast-Slow RNN to long-range model dependencies and map complex features. To represent

the words of the phrase in the form of parent-child relationships in the tree structure, Taiet al. (2015) built a tree-structured LSTM approach. Likewise, N. Wang et al. (2017) designed a Bi-GRU model coupled with an attention mechanism to learn long-term dependencies

Also, Chen et al. (2017) introduced a multiple attention LSTM to learn the dependencies separated by a large distance. Kokkinos & Potamianos (2017) suggested an attention-based GRU with a tree structure model where the informative nodes are selected based on the weighted representation of the sentence. Yequan Wang et al. (2016) created an LSTM model with aspect embedding and an attention mechanism that learns aspects in the text at a long-range.

2.3 Hybrid Neural Networks

For sentiment analysis, there is currently a substantial number of hybrid models. Here are a few that are relevant to our work. Hassan & Mahmood (2017) built an approach that augments the CNN with the LSTM layer, which replaces the CNN's pooling layer. The study by Zhou et al. (2016) invented a model that integrates a Bi-LSTM and CNN model with two dimensions convolutional and two-dimensional max pooling. Nguyen & Nguyen (2017) constructed a model that extracts the local features using a

combination of the semantic rules from the lexicon and features produced by a Deep CNN. Afterward, the produced features are fed to the Bi-LSTM to generate the final representation of the sentence that helps capture long-term dependencies. The research by R. Zhang et al. (2016) suggested a dependency sensitivity CNN model that learns the hierarchical representation with LSTM. Then the CNN applies different filters to learn the features. Yenter & Verma (2017) applied a combination of several branches of deeper CNN-LSTM for sentiment analysis.

However, our proposed model CAGRNI is different from the former in following points: the models by Hassan & Mahmood (2017), R. Zhang et al. (2016), Yenter & Verma (2017) use the LSTM, and Nguyen & Nguyen (2017), Zhou et al. (2016) utilize the Bi-LSTM whereas CAGRNI uses Bi-GRU for capturing long-term dependencies. Also, Zhou et al. (2016) approach also use two-dimensional CNN, whereas our model uses one-dimensional CNN. Furthermore, our model applies multiple CNN with different filters to allow CAGRNI to capture different local features while the former does not use. Another difference is that in (R. Zhang et al., 2016; Zhou et al., 2016), the CNN is built on top LSTM and Bi-GRU, whereas in CAGRNI, the Bi-GRU learns the features from CNN. Lastly, the former does not use the attention mechanism, while the

CAGR N applies it to select the sentiment's important words carefully.

In a nutshell, the existing approaches are more computationally expensive than our model and cannot represent the contextual information at the same level as our model does.

3 Proposed Method

This section discusses the problem definition and the details of the CAGR N model proposed to solve the problem.

CAGR N architecture is shown in Fig.1. The CAGR N consists of five main parts: word embeddings layer, convolutional and max-pooling layer, Bi-GRU layer, attention layer, and Output layer.

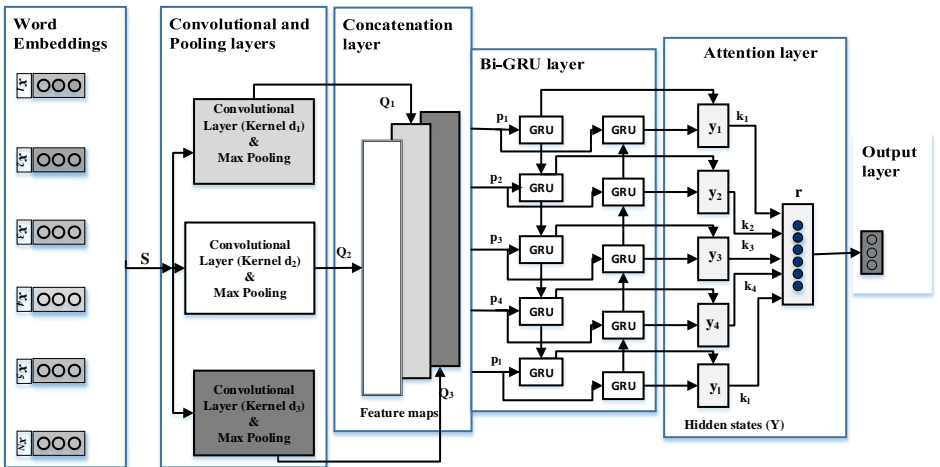


Figure 1: Architecture of Convolutional Attention Gated Recurrent Network.

The input to the model is a matrix $S = [x_1, x_2, x_3, x_4, x_5, x_N] \in \mathbb{R}^{d \times N}$ where $x_i \in \mathbb{R}^d$ is the word in the sentence, and N is the length of sentence S . We apply to the input three concurrent convolution operations with kernel size d_1, d_2 and d_3 , respectively. Afterward, the max-pooling operations are applied to the final feature maps. The resulted feature maps are concatenated and fed to the Bi-GRU. The hidden states produced by the Bi-GRU are fed to the attention layer that produces the weighted representation of the sentence. Finally, the model applies the output layer to obtain the final prediction of the sentence

3.1 Problem Definition

Formally, in this work, we propose the contextual sentiment analysis defined as follows. Let us consider the input sentence S with length N , $S = [x_1, x_2, x_3, x_4, x_5, x_N] \in \mathbb{R}^{d \times N}$ where $x_i \in \mathbb{R}^d$ corresponds to the i^{th} word vector in the sentence matrix. The purpose of our approach is to give the sentiment label to each word x_i using the contextual information. We claim that additional words in the same sentence can be used to determine the polarity of a particular word x_i . S , i.e. $[x_j | \forall j \leq N, j \neq i]$, hold the key long-term dependencies and local contextual information necessary for sentiment analysis.

3.2 Word Embedding layer

In case there is no large supervised training set, one of the alternatives to improve the performance of the models is to use unsupervised neural language models to initialize the word vectors (Socher et al., 2011). In addition, Kim (2014) proved that using the unsupervised neural language models is a good ingredient in NLP, especially in sentiment analysis. Therefore, we used GloVe¹ (Pennington et al., 2014) context predicting model, which is publicly available. GloVe word embedding inherits the benefits

¹Available from: <https://github.com/stanfordnlp/GloVe>

offered by global matrix factorization and local context methods. GloVe has been trained on Wikipedia 2014 and Gigaword 5 with a total number of 6 billion tokens. During the training process, we fine-tuned the embeddings. This word embedding method allows our model to deal with important features like contextual, syntactic, and semantic features.

Let S be the sentence input to the model. After encoding, $S = [x_1, x_2, x_3, x_4, x_5, x_N] \in \mathbb{R}^{d \times N}$ where $x_i \in \mathbb{R}^d$ is the word in the sentence, d is the embedding dimension, and N is the length of sentence S .

3.3 Convolutional and Pooling layers

We propose three concurrent convolutional layers coupled by max-pooling layers, motivated by the effectiveness of CNN models presented in the literature. The length of the sentence often determines the structure of the convolutional that is applied to the sentence representation and the length of the word, which are denoted by N and d , respectively. The convolutional layer creates a feature map M by applying a filter with the weight matrix $F \in \mathbb{R}^{d \times n}$ on a window of n words in the sentence matrix S . Equation (1) gives the i th element of the feature map M in formal terms:

$$M_i = \sigma(\sum(M[*, i: i + n] \odot F) + b) \quad (1)$$

where b is a bias term, and σ is a non-linear function, normally tanh or ReLu. $M[*; i:i+n]$ is from the i^{th} to $i+n^{\text{th}}$ word vectors in the sentence matrix. \odot is the element-wise product between two matrices. The filter F is applied to each possible window of words in the sentence vector to generate the final feature map M given by equation (2):

$$M = [M_1, M_2, M_3, \dots, M_{N-n+1}], M \in \mathbb{R}^{N-n+1} \quad (2)$$

We apply max pooling to the resulting feature map described by equation 2 because of its performance in discovering critical features with minimal computational cost. We use size two max-pooling, which halves contiguous features in the feature map M by extracting the maximum among them.

The max-pooling operation transforms the feature map M to $Q \in \mathbb{R}^{\lfloor \frac{N-n+1}{2} \rfloor}$. Formally, Q is defined by:

$$Q = \left[Q_1, Q_2, Q_3, \dots, Q_{\lfloor \frac{N-n+1}{2} \rfloor} \right] \quad (3)$$

Therefore, stimulated by the idea (Kim, 2014), we apply multiple filters with sizes 4, 5, and 6 to get the final feature map P which is the concatenation of individual feature maps Q_4, Q_5 and Q_6 . Thus, P is given by the following equation:

$$P = [Q_4 \oplus Q_5 \oplus Q_6] \quad (4)$$

where \oplus denotes the concatenation operator.

Applying multiple kinds of filters with different sizes helps capture possible local contextual features over the sentence matrix S .

3.4 Bi-directional Gated Recurrent Unit

RNNs are the type of feed-forward neural network that is specialized in the modeling input sequence and long-range dependencies. In this work, we adopt the Bi-GRU variant of RNNs suggested to overcome the vanishing and exploding gradient (Hochreiter, 1998) that the traditional RNNs suffer. Bi-GRU learns the input in forward and backward directions. Modeling the input sequence in both directions allows the model to have previous and upcoming contextual information. Therefore, this solves the bias problem that single channel RNN suffers.

The input to our Bi-GRU is the encoded features produced by the CNN layer. We represent the encoded features by $P = \{p_1, p_2, p_3, \dots, p_l\}$ with length l . The Bi-GRU is made of forward GRU and backward GRU layers. The forward GRU outputs a sequence \vec{H} , a set of hidden vectors produced in the forward direction while the backward GRU produces a sequence \overleftarrow{H} , a set of

hidden vectors produced in the backward direction. Finally, the hidden vectors \vec{H} and \overleftarrow{H} are concatenated to make the final output Y for the Bi-GRU.

The outputs for both forward and backward layers are calculated using the standard GRU updating equations described below. Formally, the GRU has different gates that govern the operations of the unit. At time step t , the GRU outputs the hidden vector h_t that is a linear interpolation of the previously hidden vector h_{t-1} and the candidate activation \tilde{h} . During this operation, the update gate z regulates how much the unit updates its activation while the reset gate r_t allows the unit to forget the previous computation and pretends that the input sequence starts.

To sum up, the computation process of GRU hidden unit j at time t is governed by the equation (5)-(8)(Cho et al., 2014):

$$h_t^j = (1 - z_t^j)h_{t-1}^j + z_t^j + \tilde{h}_t^j \quad (5)$$

$$z_t^j = \sigma(W_z p_t + U_z h_{t-1})^j \quad (6)$$

$$\tilde{h}_t^j = \tanh(W p_t + U_h (r_t \odot h_{t-1}))^j \quad (7)$$

$$r_t^j = \sigma(W_r p_t + U_r h_{t-1})^j \quad (8)$$

where σ is the sigmoid function, \odot is the element-wise multiplication, U_z, U_h, U_r are weight matrices.

The output of the GRU is a vector H containing hidden vectors $H = [h_1, h_2, h_3, \dots, h_l]$. Therefore, H is the output of the forward GRU layer, denoted as \vec{H} . While, the backward GRU does the same thing, except that its input sequence is reversed, thus, its output is denoted by \overleftarrow{H} .

The Bi-GRU layer generates an output vector $Y = [y_1, y_2, y_3, \dots, y_l]$ in which each element y_t is a concatenation of the forward and backward hidden states.

$$y_t = [\vec{h}_t \oplus \overleftarrow{h}_t] \quad (9)$$

where \oplus signifies the element-wise sum of the two hidden state vectors, forward and backward.

3.5 Attention Mechanism

For sentiment classification, not all words in the phrase are equally relevant. Therefore, we propose an attention mechanism that helps to prioritize the important word responsible for sentiment in the sentence. This study applies a simplified attention mechanism applied in neural translation (Luong et al., 2015). The attention mechanism in our model works on each output y_t of the Bi-GRU.

With this attention mechanism, our model can model the long-term information at any location in the sentence.

Let $Y = [y_1, y_2, y_3, \dots, y_l]$ be the input to the attention layer. Y is a matrix representing the output of Bi-GRU.

$$g_t = \tanh(W_m y_t + b_m) \quad (10)$$

$$k_t = \frac{\exp(g_t^T c_t)}{\sum_{t=1}^l \exp(g_t^T c_t)} \quad (11)$$

$$r = \sum_{t=1}^l k_t y_t \quad (12)$$

where l is the number of encoded-word features in the sentence, g_t is a hidden attention vector, k_t is a vector containing the normalized weight for an encoded feature of word x_i , c_t is global context vector, and r is the weighted representation of the encoded features of the sentence.

3.6 Output Layer

The output layer gets the vector r , a weighted representation of a sentence's encoded features as input. After that, for each sentiment class label, the softmax is used to estimate the probability distribution. The softmax process is defined in precise terms as follows:

$$P(y_i = k | b_i; w_k) = \frac{e^{w_k^T b_i}}{\sum_{j=1}^C e^{w_j^T b_i}} \quad (13)$$

where C is the number of classes, b_i and w_k are bias and weight for class k .

For each training sample, we use the cross-entropy loss to reduce the difference between the actual probability distribution and the anticipated probability:

$$L_i = -\sum_{k=1}^C t_k(y_i) \log P(y_i = k | b_i; w_k) \quad (14)$$

where $t_k(y_i)$ is a one-hot vector that represents the actual sentiment label distribution, $P(y_i = k | b_i; w_k)$ is the predicted probability.

Data	S	Train	Val	Test	C
IMDb	50000	37500	6250	6250	2
SSTb	11855	8544	1101	2210	2

Table 1: Statistics of the datasets used

S, C denote the number of samples and classes, respectively.

4 Experiments

This section presents the details of the datasets used to evaluate the effectiveness of the CAGRNet model, CAGRNet hyper-parameters, and training details. Finally, it shows the experimental results obtained by CAGRNet and the comparison with baseline models.

4.1 Datasets

We evaluated the performance of our model on IMDb² (Maas et al., 2011) Large Movie Review and SSTb³ (Socher et al., 2013) Stanford Sentiment Treebank datasets. We evaluate the model for binary sentiment classification. For the first dataset IMDb, samples are balanced 50% for training and 50% for testing. In addition, the reviews in this dataset contain multiple sentences. While evaluating our model, we used 75% for training, 12.5% validation, and the remaining 12.5% for testing. We did not follow the proposed distribution because we wanted to give our model many training samples and provide a validation set. The second dataset, SSTb, consists of 11,855 movie reviews collected from the Rotten Tomatoes site. The reviews in the dataset contain a single short

² Available from: <http://ai.stanford.edu/~amaas/data/sentiment/>

³ Available from: <https://nlp.stanford.edu/sentiment/>

sentence per review. The statistics for each dataset are presented in Table 1.

4.2 CAGRNN Hyper parameters

The embeddings with dimension 200 that GloVe initialized are the inputs to the model. We utilize three channels in the CNN model, each with a one-dimensional convolutional layer with 256 filters and a kernel size of $d(4,5,6)$. For each convolutional layer, we employ the rectified linear units (ReLU) activation function. In addition, each channel employs a two-size max-pooling layer. On the IMDB and SSTb datasets, the Bi-GRU uses the hidden state of size 300 and 70, respectively. On both datasets, the number of epochs used to train the proposed model differs between (3,8). We set the batch size to 32 for each iteration of the training procedure. To prevent our model from overfitting, we applied the early stopping and dropout (Srivastava et al., 2014). We applied the dropout probability between 0.5 and 0.8 after the convolution layer and after the Bi-GRU layer. The model was trained via Adam optimizer (Kingma & Ba, 2015) with default parameters. We minimized the cross-entropy loss given by equation 14 when training our model. Finally, we used the Keras Python package with the TensorFlow backend to create our model.

4.3 Baseline models

We compare the effectiveness of our proposed model to the following state-of-art approaches:

PL(Maas et al., 2011) is a probabilistic model that performs sentiment analysis. The IMDB dataset was designed in this work.

RNTN(Socher et al., 2013) is a well-known recursive neural tensor network that represents the sentence in the form of a tree. The SST dataset was created in these results.

CNN-multichannel(Kim, 2014) is a commonly used model that applies multiple convolutional with different filters to perform sentiment analysis.

DCNN (dynamic CNN) (Kalchbrenner et al., 2014)is a graph-based model of the features of a sentence.

DeepCNN(Santos & Gatti, 2014) uses character information and sentence representations for the sentiment classification.

CNN (Semantic CNN) (Yin et al., 2017)augments the features extracted by CNN with sentiment information from the lexicon.

CNN-SA (CNN Sensitivity Analysis)(Y. Zhang & Wallace, 2017)performs the analysis of effect of CNN architecture to the results in sentiment analysis.

	Model	IMDb	SSTb
Baseline models	CNN-multichannel	—	88.1
	DCNN		
	DeepCNN	—	86.8
	SCNN	—	85.7
	CNN-SA	—	87.9
	RNTN	—	85.49
	CNN-LSTM	—	85.4
	Tree-GRU	—	88.3
	BLSTM-2DCNN	—	89.5
	DAN	—	89.5
	DSCNN	89.4	86.3
	PL	90.7	89.1
	HRL	88.89	—
	CBA+LSTM	90.92	—
	Deep CNN-LSTM	90.1	—
	89.5	—	
Ours	CGRN	91.39	89.71
	CAGR	91.50	89.83

Table 2: Results of our models and baseline models

CNN-LSTM(Hassan & Mahmood, 2017)is a hybrid approach that uses an LSTM layer to replace CNN's pooling layer.

Tree-GRU(Kokkinos & Potamianos, 2017)represents the information in a sentence as a tree, with nodes picked according to the weight of each word.

BLSTM-2DCNN(Zhou et al., 2016) is a combined approach of BLSTM with two-dimensional CNN.

DAN (Deep Averaging Network)(Iyyer et al., 2015) is a simple but efficient model that performs the sentiment analysis by ignoring the syntactic structure of the inputs.

DSCNN (Dependency sensitivity CNN) (R. Zhang et al., 2016)uses an LSTM for sentences representation and applies CNN in extracting the features.

HRL(Yiren Wang & Tian, 2016)is a Hybrid Residual LSTM model that performs sequence classification by combining the ResNet connection with LSTM.

CBA+LSTM (Cognitive Based Attention LSTM)(Long et al., 2017) is an approach that represents the attention of a given the word in a sentence. Also, it captures the attention of a given sentence in the document.

Deep CNN-LSTM(Yenter & Verma, 2017) applies multiple branches of hybrids of CNN and LSTM.

4.4 Experimental Results

The evaluation results achieved by our models and baseline models are shown in Table 2. We report the results in terms of accuracy expressed in percentage. It is observed that our proposed model CAGR_N obtained superior results compared to the state-of-the-art models. CAGR_N improved the performance of both datasets. CAGR_N raised the accuracy by 0.58 on IMDB and 0.3-3 on SST_b. Among the results presented in the literature, the model with the highest accuracy is Hybrid Residual LSTM (HRL) (Yiren Wang & Tian, 2016) with 90.92% on IMDB and Tree-GRU (Kokkinos & Potamianos, 2017) with 89.5% on SST_b.

The good performance of our model is related to the advantages of using contextual information extracted by the combined approaches. In addition, the attention mechanism helps our model perform a wise selection of important words containing the sentiment information at any location in the sentence. The results reveal that our model, without attention, CGR_N, got comparable results to the baseline models.

In brief, the experimental results strongly agree with our idea of using contextual information to perform the sentiment classification.

5 Conclusion

In this paper, we augment the CNN with a Bi-GRU joined with an attention mechanism to perform the contextual sentiment analysis. In particular, the multiple convolutional applied helps the model to extract possible local features by retaining the order of the input sentence. On the other hand, the Bi-GRU learns global features. Besides, the attention mechanism helps the model to select the important words responsible for the sentiment information. We evaluated the effectiveness of the proposed model for binary sentiment classification on IMDB and SSTb datasets. The obtained results reasonably agree with our idea of using contextual information to realize contextual sentiment analysis.

The experiments, including performing various ablation experiments of our model's components, will be done in future work. In addition, our model can be applied to other sequence learning tasks. Specifically, future work in neural machine translator can investigate whether this can enjoy the beauty of our model.

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ELECTRONIC VOTING SYSTEM VIA GSM

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ABSTRACT

Voting is a right for every citizen allowed to vote in democratic countries. Different countries are having manual or electronic systems to elect their Constitutional Law and their different leaders like President, Prime minister, Member of parliaments, senates, etc. Electronic Voting System via GSM will provide additional facilities to the voters and candidates, to make election more flexible and efficient compare to the traditional election. We will use Global System for Mobile Communication to facilitate the candidates and voters to use this technology to register, elect their candidates from their places and the total votes will be published in a very short time period. This system is capable to enhanced voter verification and mobility while maintaining voter privacy with One Time Password (OTP) generation. Our main objective is to design a secure GSM Mobile Communication Electronic Voting (GMC-EV) model to establish secured connectivity and One Time Password (OTP) based authorization during GSM based electoral process to enhance the authentication of the system. We will use Software Development life Cycle model as our methodology to implement our Electronic Voting System via GSM. The key findings is the test bed simulation of the proposed GSM-Electronic Voting System, the other key findings include the comparison of the time analysis of Secure Hash Algorithm 1(SHA-1) and Secure Hash Algorithm 2(SHA-2). Our system will based on GlobalMobile Communication Electronic Voting as different people are now having smart phones, One Time Password will be generated for every voter. As a recommendation, the Election Commission of Voting System should train the key parsons who will make the

follow up, different activities of the elections from the beginning to the end of the election.

Key words: GMC-EV, OTP, Secure Hash Algorithms, GSM-SMS, IMEI

1. INTRODUCTION

Elections have a long history, different countries in the world use different methods for voting the leaders. In a Democratic country elections are considered as the key factors for the development of the nation as it provides the voter with opportunity be a part of the policy making and country building. The process of election involves co-ordination of different mechanisms involving the registration of the voter, candidates and examining the information provided by the voter as well as candidates. Selecting the information, maintaining confidentiality of the information, conducting a free and air election turns to be a tedious process. To have a free and fair election no ambiguity in any of the mechanism should be allowed, in failing to do so will fail the motto of the democracy. Overcoming these problems and with the advancement of technology also the need to reduce cost, improve security, efficiency and reduce human interface gave rise to the idea of Electronic Voting (Kabandana, 2016).

This study introduces a secure prototyped GMC-EV for establishing robust and efficient broadband connection between the cell phone (non-smart devices) and centralized server. The proposed GMC-EV intends to perform a secure communication considering communication and Mail Application Program Interface (API) in less congested traffic in wireless channels. As the number of internet users is increasing day by day, it results in a much insecure channel regarding readability, availability and

there are intruders who are overhearing to interrupt communication.

The novelty of this paper is as follows: It adopts the concept of Secure Hash Algorithm (SHA-1) and SHA-2 to solve general E-voting issues. If the registered users are not verified properly thus vote given for a particular candidate can be interrupted and manipulated easily by the intruder in a communication channel. The solution presented in this paper is to introduce client and server level encryption and decryption of voter's data using hop based stenography encoding and decoding mechanism SHA value. This paper also conceptualizes a theoretical cryptosystem based on theoretical analysis of SHA-1 and SHA-2 algorithms to accomplish enhanced performance of the proposed system(Neha, 2016).

The proposed OTP based crypto system configured and enabled in both server (GSM/application) and client side which brings out the novelty by reducing the computational complexity and processing time. This paper also highlights how the experimental outcomes are initiated using software and hardware combined prototype model and its significant impact on achieving more security in e-voting systems. Various conventional studies in literature that focused on mitigating security issues associated with electronic voting system but very fewer of them are found to have a notable contribution to improve the performance metrics of the conventional e-voting mechanisms from security aspect (Weldemariam et Adolf, 2010).

The researchers in designing and developing efficient e-voting systems to provide solutions to the existing models irrespective of any design and technical constraints (Lai et al., 2009). Traditional election system is causing many problems in registration of the

voters, candidates, more time needed to elect the candidate and count the votes and also there is no trust of the results. Hence, the proposed GMC-EV aims to mitigate the current security issues prevailing in the conventional hardware and software based e-voting system.

This paper further expands the problem identification in the traditional strategies followed by research methodology and algorithm implementations. The algorithm design and mathematical modeling highlight significant impact of OTP generation on a centralized server (GSM based) and the security aspects are measured considering the selection of performance parameters for both SHA-1 and SHA-2 algorithms. The useful performance parameters collection shows how the proposed GMC-EV outperforms conventional hardware/software combined E-voting systems regarding security as well as computational complexity.

2. PROBLEM IDENTIFICATION

This section introduces some of the significant constraints prevailing in the conventional hardware and software based E-voting mechanisms. The conventional GSM-based e-voting systems incorporate various less secure cryptosystems to protect data. It can be seen that scrambling the original data for converting it into another unreadable format makes no sense if the third parties get access to the modified data; as they can easily decrypt it.

It also happens that if the third parties are over hearing the communication channel during the data transmission from the sender to the receiver node, they can quickly perform an attack to modify the data. The existing security challenges in GSM based

E-voting system make it more susceptible to the attacks such as rotation, translation, etc (Yang et al., 2006). To mitigate the above-mentioned issues, our paper adopts the concept of OTP generation along with performance of SHA-1 and SHA-2 hash algorithms to protect the sender and receiver authorization in the wireless channel.

Therefore, it is essential to formulate a robust authentication mechanism which can be further emerged with the conventional hardware and software combined E-voting technologies. MatejTravnicek et al. suggested that the implementation of E-voting considering secure wireless medium and embedded electronics only can accomplish success, if it is deployed into the system as per the electoral need (MatejTravnicek et al., 2012). However, the overall process for election is almost the same, but it differs from country to country in terms of complexity, system installation and cost (Lauer et al., 2004). The installation of contactless Integrated Circuit (IC) for E-voting and its integration poses vulnerability on the communication medium.

3. RESEARCH METHODOLOGY

The aim of this research is to design a secured GSM communication based E-voting mechanism which mainly obtains web security by integrating secure Hypertext Transport Protocol (HTTPS) with the Application Program Interface (API). The proposed system also initiates HTTPS to work with encrypted Secure Socket Layer (SSL) transport mechanism. The SSL also provides an efficient interactive and reliable end-to-end security services to the higher layer protocols of Open Systems Interconnection (OSI) model such as Transmission Control Protocol/Internet Protocol (TCP /IP) and many application and

presentation layers protocols. SSL services use the concept of Rivest, Shamir and Adleman(RSA) for exchanging RSA session keys over the transport and session layers for authenticating the session keys (NaQi and or &, Wei Wei, 2013).

The proposed system also incorporates RSA-based encryption technique which further activates Message Authentication Code (MAC) to further provide secure message integrity over higher layer protocol like HTTP. The HTTP socket layer basically allows the GSM server side and the client's mobile side to verify the communication channel by a negotiation over MAC algorithm and session keys to protect the one-time session. The SSL handshake protocol mainly includes 4-phases client and server level authentication stages to establish a secure communication using HTTPS client and server side socket. However, various conventional studies previously initiated the Transport Layer Security (TLS) script on authenticating the client and server based communication scenario but the broad applicability of SSLv3.3 makes it appear totally efficient as compared to the conventional TLS (Thyla van der Merwe,2018).

The proposed system uses SSLv3.3 for authentication of phase 2 and phase 3 where server may send certificate, exchange key objects and validate transmitted client hello signals in terms of certificate and server key exchange processes. The following diagram shows the tentative system architecture of the proposed GSM (centralized server) based communication scenario.

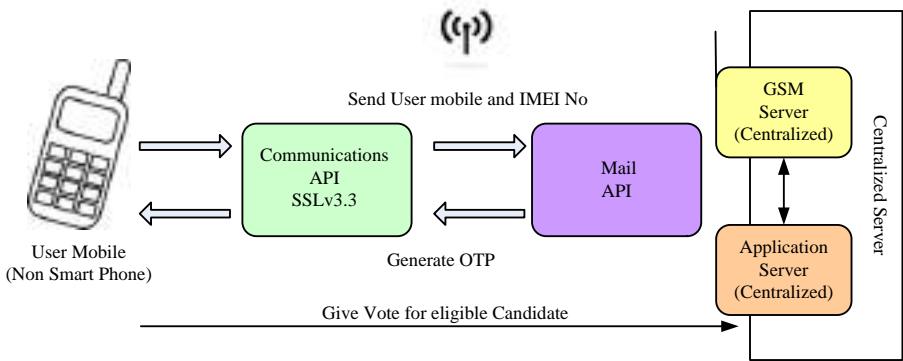


Figure 1: Proposed GSM based Secure E-voting Architecture

The above figure1 shows how a voter can be validated for giving a vote to a particular candidate stood for election. The proposed system validates a user device by tracking its International Mobile Equipment Identity (IMEI) number. Initially, the voter provides its user mobile number and unique IMEI number to the centralized server using client interface system.

The communication API establishes a communication ~~in~~ between the GSM server and the application server to check whether the voters IMEI number and mobile number exists in the election commission's online database or not, if it exists then it will encrypt the IMEI number and phone number using the proposed GMC-EV. It further encrypts the IMEI and phone number and initiates a 'HELLO' message from the GSM communication port. If the receiver end receives the HELLO message, then it requests to the server for OTP. The GSM server then generates the OTP and acknowledges it to the cellular device (voter). The voter authenticates itself by providing the same OTP to the GSM server and gives vote for the eligible candidate. The proposed system

uses the following modules for client mobile IP authentication process:

a. One-Time Password Generation by GSM Server

The proposed system exploits fully the OSI model where the media access control layer and logical link control (LLC) layer encodes and decodes the transmitted data packets into logical (0 to 1) representation. The data link layer also provides a mechanism for error minimization and well synchronization in the transmission channel. It also provides an interactive solution to map the physical address of GSM device ports into link layer data frames for good synchronization. The proposed system also activates GSM server to initialize OTP to provide better security aspects into client authentication module. Therefore, the random generation of OTP from GSM server makes client authentication process very invulnerable to any malicious network attacks (Sagar, 2013).

It appears to be very effective as the server generated OTP can be used only once, and the session layer expires session on the delay of providing the received OTP and its respective verification process by the GSM server module. As the OTP generation concept considered as invulnerable to any passive attacks and sniffing thus it poses better security aspect. The proposed system also introduces a unique mathematical algorithm to represent the OTP generation process by GSM server which depicts well time-synchronization between the authentication server and client e.g. voter. The random number generation procedure is further fed into a one-way function.

b. Integration of Secure hash functions into the proposed system

The proposed GMC-EV is designed by adopting the non-invertability of a safe hash function. It defines relatively the easiest way to compute the hash based data in a forward direction but poses computationally inefficiency to the invert notion. The proposed system also enables SHA-1 and SHA-2 algorithm at the server side where a hash function h_f takes a variable length message m and convert it into fixed length $h_f(m)$ SHA-2. The proposed GMC-EV applies the SHA as a hash function relatively pretenses better security aspects as compared to the conventional ones. The notable properties of the hash function are:

- It can be applied to variable length data sizes.
- It produces a fixed length message digest.
- $h_f(m)$ depicts ease of computation for any variable length messages considering both hardware and software combined systems in real time.
- The security features of SHA algorithm highlights that it is computationally infeasible to find the value of original message m after converting it into a message digest of fixed length such that $h_f(m) \rightarrow M$
- The one-way property of hash algorithms also makes it computationally infeasible to find the original message $m \neq n$ while $h_f(m) = h_f(n)$.

- The SHA algorithm also known for strong collision resistance as technically it is not feasible to find any pair (m, n) such that $h_f(m) = h_f(n)$.

The above-mentioned are the characteristic features of secure hash algorithm by its one-way features and high cryptosystem formulation.

- **SHA-1 Secure Hash Function**

The secure hash algorithm is used in the proposed GMC-EV model. In this proposed system, SHA-1 takes input message as a 2^{64} bits data and produce 150 to 160 bit message digest. The message digests produced by the SHA-1 consists of fixed length output (Harshvardhan Tiwari, 2010).

c. Message Authentication Code

The proposed GMC-EV model also adopted the concept of Message Authentication Code MAC for protecting/encryption GSM generated OTP. Basically, the intruders can overhear the channel and perform active attacks, i.e. falsification of data and transactions. The use of MAC, basically integrated into the proposed GMC-EV helps to verify the sender and the content of the data packet being transmitted through the channel. The proposed system uses the above-stated cryptosystems on GSM server module, which minimizes the probability of passive attacks in the transmission medium (channel) (Jerone B. Alimpia, 2018). Since sometimes the long encryption process to encapsulate the data increases the use of resources and complexities thus there is a need for data packet authentication irrespective of data encryption.

4. PROPOSED GSM ARCHITECTURE AND TECHNICAL SPECIFICATION

This section introduces the GSM network architecture which is embedded into the proposed system. The most prominent features and its respective detailed description are discussed 4.1.

4.1 Architecture

As GSM communication is considered as one of the most widely used telecommunication technologies in the modern world, it is further incorporated in the proposed GMC-EV system. It also has been utilized in the systems like Universal Mobile Telecommunications System (UMTS). The design specifications and its important features are discussed below.

In the proposed system, the client side uses a non-smart phone which consists of the following two parts:

- a. Mobile Device/Handset:** The proposed system uses a mobile device on the client side to communicate with the server for E-voting purpose. By using the handset, the mobile device can receive the OTP and it can give a vote for the eligible candidate.
- b. Subscriber Identity Mobile (SIM):** The SIM which is a portable chip contains two types of user information which are as follows.

- Subscriber Identity
- Subscriber Authentication Information

The subscriber authentication information associated with the proposed GSM kit contains the International Mobile Subscriber Identity (IMSI). IMSI number is defined in a way where it is a unique number for each subcarrier. The IMSI number includes the unique identity of the sub carrier in the network as well as it also contains the information of the home or the country network.

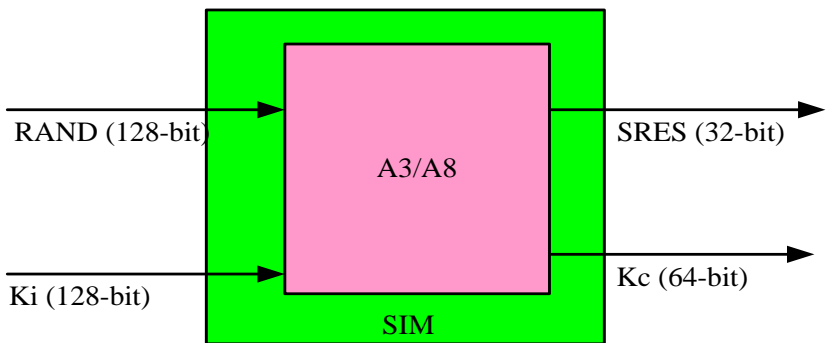


Figure 2: GSM SIM Architecture for the proposed E-voting system

The proposed GMC-EV system considers a K_i encryption parameter. The GSM SIM randomly generates 128-bit number and allocates it to the particular subscriber. All the keys and challenges are further stored into the GSM server. The SIM internal design is highlighted in figure 2 and it shows that it plays a crucial role during the authentication process of user and how it generates the OTP for each user. It can also be seen that the signal transmission through wireless medium only happens when the

SIM is inserted into the GSM module, and it activates the services for online process. The random number is initiated and process through the communication channel to the mobile station. The SIM also performs the same operations during the signal transmission. The Signed Response (SRES) which is computed initially is compared with the current SRES by the network. If they match in both the client and GSM server side, then it is said that the SIM is authenticated.

4.2 International Mobile Equipment Identity

The proposed system also incorporates tracking of voter's non-smart phone (IMEI) number which is unique to every user. The IMEI number of the mobile phone is connected to the GSM network and stored in a database namely Equipment Identity Register (EIR) contains all the valid mobile phone equipment.

4.3 GSM-SMS

The proposed GMC-EV system also initiates GSM based SMS to establish communication in between the client and server. The SMS over GSM network uses message length up to maximum 160 alphanumeric characters and cannot contain any image or graphic object files. The reason, GSM service is integrated into the proposed GMC-EV system got high data speed, cheap rates and guaranteed the successful transmission of data packets. The Short Message Service Center (SMSC) handles the message transmission in case the cellular device is switched off and tracks down the transmission until and unless the message reaches its destination. SMSC relays the data packets to the appropriate receiver by locating its coordinates on Home Location Register (HLR). If the receiver is out of coverage, SMSC store the message into its database, by the time the receiver becomes active

and comes within coverage range the HLR immediately notifies the SMSC. The following figure 3 shows the GSM message delivery services.

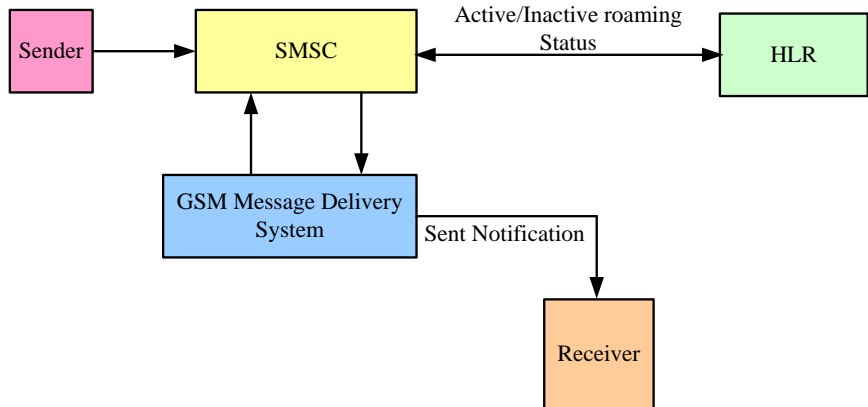


Figure 3: GSM SIM Message Delivery System

4.4 Extensible Authentication Protocol (EAP)

As highlighted and discussed in the previous part, there are some security contemplations with the GSM framework. One approach to enhance the safety in GSM is to utilize it together with the Extensible Authentication Protocol (EAP). By doing this both 2-ways confirmation and more grounded end-to-end security can be figured out. This part exhibits the EAP which is characterized in the RFC3748 and the detail for use in versatile situations described in RFC4186EAP-SIM (2006). EAP is a verification system which underpins various confirmation strategies. It regularly runs specifically over joint information layers, for example, Point to Point Protocol (PPP) or IEEE 802, without

requiring IP. EAP was initially expected to be utilized over PPP, yet has additionally been received by the IEEE 802.11i standard.

- **Types of EAP Messages**

EAP uses four types of messages. These are:

- Request: Messages sent from the authenticator to the supplicant
- Response: Messages sent from the supplicant to the authenticator
- Success: Sent from authenticator when access is granted
- Failure: Sent from authenticator when access is denied

4.5 ALGORITHM IMPLEMENTATION STRATEGIES

The proposed GMC-EV is designed considering hardware and software application based the combined system. The hardware is a GSM tool embedded with a centralized server running a software application on the back end.

Algorithm One: Admin Module running on a Centralized Server
| Add Voter/User

Input: $\eta (A_{ID} \ Y \ A_{PASS})$.

Output: Add V_i , Declare Election Schedule (E_s), Election Results (E_R)

Start

Step 1: Initialize A_{ID} , A_{PASS} , V_i , U_i , η_{Server}

Step 2: if (login == 1)

Step 3: Activate $\rightarrow A_{Module}$

Step 4: for ($i \leftarrow 1 : n$)

Step 5: Add $\leftarrow V_i$ {Name, Email, Mobile, Password, IMEI No}

Step 6: If (Successful)

Step 7: Generate $\leftarrow V_{ID}$

Step 8: Add $\leftarrow V_i$

Step 9: Declare $\leftarrow E_S \mid E_R$.

End

The above-mentioned algorithm shows the mode of admin module communication with centralized server and it adds voters. Firstly admin logs into election commission system database to gain access to the application server. $\eta (A_{ID} \ Y \ A_{PASS})$ signifies a function which denotes that admin should enter its respective Admin ID (A_{ID}) and password (A_{PASS}) login into the centralized system (web server). Voter, user, and centralized application server are denoted by the variables V_i, U_i, η_{Server} .

Algorithm Two: Admin Module running on a Centralized Server
| Add Candidates

Input: $\eta (A_{ID} \ Y \ A_{PASS})$.

Output: Add C_i , Declare Election Schedule (E_S), Election Results (E_R)

Start

Step 1: Initialize $A_{ID}, A_{PASS}, C_i, U_i, \eta_{Server}$

Step 2: for ($i \leftarrow 1:n$)

Step 3: If ($V_{ID_i} \neq$ Exist in Application Database)

Step 4: Add $\leftarrow V_i$

Step 5: Else

Step 6: Register $\leftarrow C_i$ {Party Name, Name, Email, Mobile, Password, Election Type}

Step 7: Declare $\leftarrow E_S \mid E_R$

End

Algorithm Thee: Election Results (E_R)

Input: $\eta (A_{ID}, A_{PASS})$.

Output: Declare Election Schedule (E_S), Add C_i , V_i , Election Results (E_R)

Start

Step 1: Initialize A_{ID} , A_{PASS} , C_i , U_i , η_{Server}

Step 2: Election Schedule \leftarrow Admin

Step 3: for ($i \leftarrow 1:n$)

Step 4: If ($V_{ID_i} \neq$ Exist in Application Database)

Step 5: Add $\leftarrow V_i$

Step 6: Else

Step 7: Register $\leftarrow C_i$ {Party Name, Name, Email, Mobile, Password, IMEI, Election Type}

Step 8: Declare $\leftarrow E_S$

Step 9: Voting process $\leftarrow V_i$

Step 10: Result $\leftarrow E_R$

End

Algorithm two and three, depict how a candidate can be registered considering its voter ID by the centralized web server. It also checks whether a voter who is nominated for candidate position still exists in the centralized database or not. If it exists, the algorithm will add that voter as candidate else it will notify the person to register himself as a voter again. The proposed system also incorporates a GSM server which communicates with the web server and the mobile phones using communication interfaces API.

- **Integration of Communication API into the Proposed System**

Java communication API version 3.0 enabled as an extension. It is a tool which defines a set of instructions that perform a specific communication in between two different units through a wireless channel medium. The proposed E-voting mechanism incorporates the Java communications API as a platform-independent tool, embedded with both sender and receiver end GSM system.

Functional Aspect

In this paper, the java communication API namely Javax.com provides an application independent interface GSM RS hardware serial ports which are denoted by COM1, COM2, COM3, etc. It

provides very limited access for data transfer to the parallel ports of RS GSM hardware modules (IEEE-1284).

The proposed system enables *Service Switching Point*(SPP) mode in GSM RS-232 hardware module where the implementation of the data transfer process has been carried out using Solaris Scalable Processor Architecture (SPARC), Solaris x86 and Linux x86. The proposed client's product line is configured with the port mapping extensions of the GSM kit to allow the admin module for specifying the port locations as well as their visibility regarding names and annotated references.

API serial features

Following are the API serial features used for the implementation of GSM based E-voting system.

- Count of ports (supervisor and client configurable port mapping)
- Port arrangement (baud rate, speed, stop bits, equality)
- Access to EIA232 standard *Data Terminal Ready*(DTR), *Code Division* (CD), *Cordless Telephone System* (CTS), *Radio Technology Somfy*(RTS) and *Data Set Ready* (DSR) signals
- Exchange of information over RS-232 ports
- Equipment and programming stream control choices
- Get cradle edge control

- Offbeat occasion choice for warning off:
- Information accessible on a RS-232 port
- Port equipment line level changes
- Port possession changes inside a solitary Java Virtual Machine (JVM)

Integration of Mail API into the Proposed System:

The admin module software application running on the centralized server back end integrates another built-in package named as Mail API interfaces. It is used in composing, write and read electronic messages for both sender (voter's mobile) and receiver (centralized server) modules. It provides a platform independent interface framework which can process a set of instructions for sending and receiving SMS.

The proposed system primarily incorporates two different types of packages which are javax.mail and javax.mail.event activation packages respectively. These packages encapsulate the core classes of mail API. It also facilitates the centralized server admin module by registering the voters and the candidates. Mail API core classes used in the proposed system for establishing secure and reliable communication in between the centralized application server and GSM server. Moreover, it is also extended to the user mobile and server communication establishment based on cell phone IP.

The following figure 4 represents the sequence diagram of the proposed GMC-EV model. It also shows how the message transmission through a wireless link has been carried out with respect to time (t).

Figure 4: Proposed E-voting Mail Interface Sequence Diagram

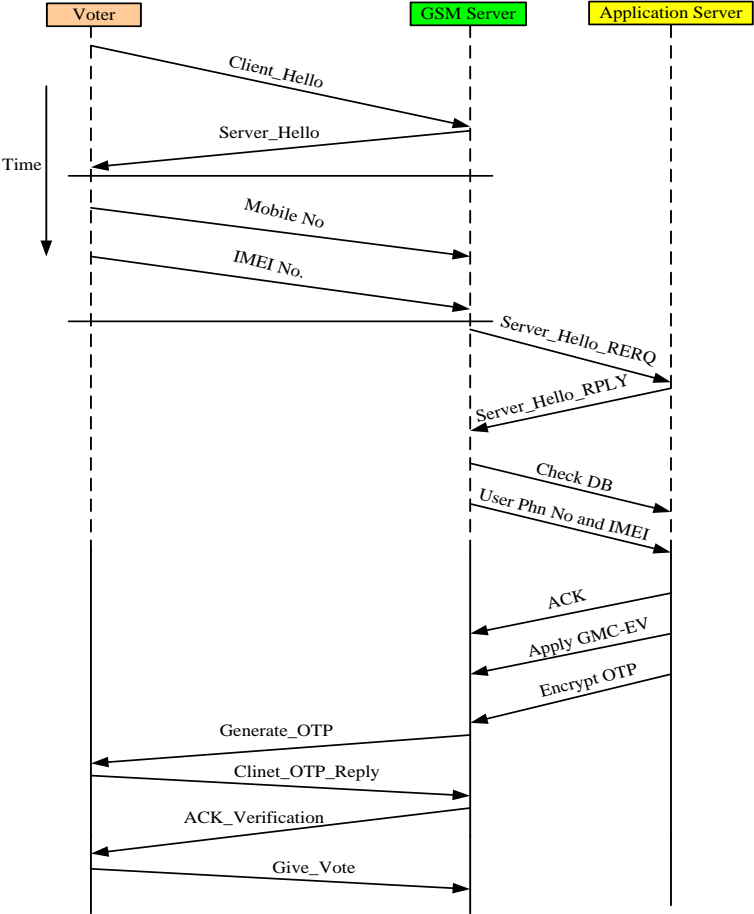


Table 1: Experimental test bed results

5. RESULTS AND DISCUSSION

This section discusses the important findings obtained from the test bed simulation of proposed GMC-EV system. It also highlights a comparative analysis performed, considering the (processing /computation) time of conventional SHA-1 and SHA-2 algorithms. The timing analysis of SHA-1 and SHA-2 depicts that SHA-1 achieves very less processing time and higher security aspects as compared to the conventional SHA-2. Hence, SHA-1 can easily be integrated into the proposed GSM-EV model. The experimental prototyping also shows the ease of computation of proposed GSM-EV model and its extensive applicability into non-smart phones, because of its much feasibility and robustness. The light weight and easy implementation features make it more attractive as compared to the conventional E-voting systems (i.e. conventional GSM based Intelligent Polling System). The following table highlights the outcomes of the timing analysis obtained from the experimental test bed.

File Size (KB)	Computation Time (Sec)	
	SHA-1	SHA-2
10	0.126	0.342
15	0.387	1.154
20	1.285	3.675

Table 2: Impact of Processor on Execution Time

The above table also highlights how SHA-1 achieves very less computation time (sec) with the increment of file size as compared to theSHA-192. The following table 2 shows the manual calculation of execution time regarding processing speed and iterations for conventional systems and the proposed GMC-EV model. The calculation has been carried out considering a test bed simulation for core i3, i5, and i7 CPUs. It shows that the proposed GMC-EV takes fewer resources during the computation and poses very less execution time as compared to the current e-voting applications. The comparative analysis of execution time is highlighted in the following table 2 and 3.

Iterations	EXECUTION TIME					
	Conventional Polling System		Intelligent	Proposed System		
	Core-i3	Core i5	Core-i7	Core-i3	Core i5	Core-i7
35	0.724	0.633	0.411	0.047	0.021	0.012
110	0.755	0.656	0.419	0.063	0.024	0.012
160	0.736	0.658	0.435	0.080	0.036	0.014
250	0.757	0.689	0.477	0.092	0.048	0.019
320	0.778	0.694	0.481	0.109	0.056	0.023
370	0.809	0.752	0.521	0.125	0.064	0.028
480	0.810	0.753	0.521	0.146	0.069	0.035
530	0.811	0.764	0.535	0.157	0.072	0.039

580	0.812	0.788	0.552	0.174	0.072	0.044
650	0.813	0.797	0.569	0.187	0.077	0.048
760	0.934	0.802	0.578	0.209	0.081	0.055
1100	0.995	0.838	0.588	0.262	0.093	0.061
Iterations	EXECUTION TIME					
	Existing System			Proposed System		
30	0.727			0.047		
100	0.754			0.063		
170	0.734			0.080		
240	0.756			0.092		
310	0.771			0.109		
380	0.800			0.125		
450	0.809			0.146		
520	0.831			0.157		
590	0.8705			0.174		
660	0.872			0.187		
730	0.936			0.209		
1000	0.994			0.262		

Table 4 shows a comparative analysis of the proposed system with touch screen system where the performance parameters are

considered as processing time in seconds and iterations. It also depicts how the proposed GMC-EV model performs better than the Touch screen E-voting systems.

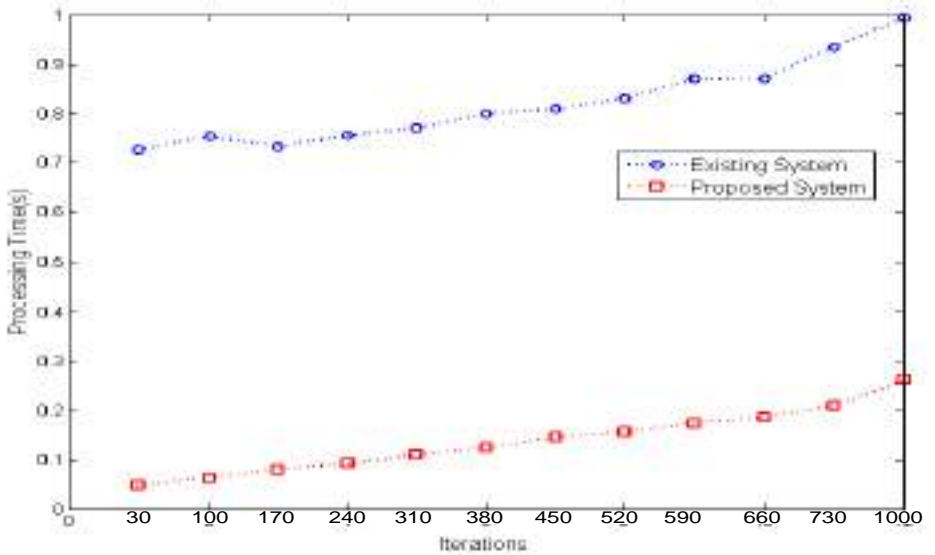


Figure 4: Resultant Outcomes of Processing Time

6. CONCLUSION

This paper presented the proposed GSM based secure e-voting system, specified as GMC-EV system and its significant impact on enhancing the security features of GSM communications over wireless channels. This topic also highlights the mathematical algorithms depicts the proposed GMC-EV design theoretically. The experimental outcome shows that the proposed GMC-EV performs better than the Touch Electronic Voting System.

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**REPLICATION OF SUCCESS FOR
SUSTAINABLE RURAL LIVELIHOOD
DEVELOPMENT WITH INCLUSIVE
INNOVATION IN RWANDA**

**A CASE OF NEIGHBOURING
COMMUNITIES INNGERUKA SECTOR,
EASTERN PROVINCE**

By: MFITIRYAYO Jean de Dieu

ABSTRACT

The current paper intended to examine the replication of success for sustainable rural livelihoods development with inclusive innovation in Rwanda. It was undertaken under four specific objectives which involved to determine the features of replication of success among neighboring communities, to examine the types of channels for replication of success, to assess the extent to which the replication of success sustains the neighboring communities' livelihoods and too determine the moderating effects of replication of success among neighboring communities in Ngeruka Sector.

The data underlying this study were collected within 10 months of fieldwork since November 2020 to August 2021 in 12 villages of Ngeruka sector in Bugesera District- Eastern Province. Among 800 most vulnerable people, the 300 were randomly selected among others to participate in the study. The qualitative and quantitative data were collected using 300 community member-based questionnaires, administered in the local language. The participants to whom the questionnaires were addressed corresponded to 293 while other 7 were interviewed.

The 12 Focus Group Discussions were also conducted to 24 groups included the 12 pre-assisted groups while other 12 referred to the recipients of successes. In the absence of an official census, a household register was compiled consisting of 3,170 community members (in neighboring communities). It was seen that, this approach helped to reduce and combat conflict among households as resulted from poor living conditions (33.6%) and reduced the culture of dependence on external or foreign donors or to remain a burden on the government with 61.7% of respondents affirmed. The study explained on how the

mutual support among the communities themselves was a good way to keep them from migrating to other parts of the country for searching for lives, rather enabled them maintaining their community (63.6%). In addition, infrastructures and other natural resources were sustainably managed; for example, the people were able to use their resources wisely and make them productive such as land (76.6%), water with 3.6%, livestock (67.3%) and money with 64.3%.

This approach identified itself as the only way to help communities cope with their problems and be able to find lasting solutions. Empowering communities as well as giving them opportunity to make decision have increased their motivation and reduce their resistance to community changes. The study encouraged public, private and non-governmental organizations to take advantages on the applicability of replication of success towards the community resilience and sustainable livelihoods development. All concerned organizations are recalled to help communities bearing the culture of ownership spirit as the real pathway for the replication of success to take place. The findings of this study are highly privileged to recommend the government of Rwanda to adopt the replication of success related policy among others.

Key words: Replication of success, reciprocity, social support, rural livelihood, community self-help, sustainable development, innovation

1. Background to the study

Establishing the concept of sustainable rural livelihoods, as derived from sustainable development, requires an understanding of the complex interaction between at least the sociopolitical, economic and ecological spheres, with humankind at the centre (MacDonald, 1994). Gause (2007) describes this interaction as the linkage of citizens to nature (ecological) and to one another (sociopolitical) to create healthier and vital neighborhoods (economic); it involves residents in community governance and environmental stewardship, creating sustainable communities. Sustainable rural livelihood development is situated within the broader category of sustainable development, a planning approach that has gained considerable traction since the 1970s. The best-known definition of sustainable development is “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (WCED, 1987). Initially, sustainable development focused on its environmental aspect, recognizing the necessity of meeting the complex needs of people, while maintaining the integrity of natural systems that support all life (Silberstein and Maser, 2000). Dasmann (1975) believed that sustainable development should be the rational use of the environment to provide the best possible sustainable quality of life for humanity. In other words, “using environmental resources to provide a sustainable living environment for as long as possible”, with the quantitative and qualitative needs of people determining the quality of life.

Speaking of the conservation of our environment, Rwanda is a small, landlocked country in central east Africa. It is one of the most densely populated countries in the world, with more than

400 inhabitants per square kilometer (Bertelsmann Stiftung, 2014). Considered to be among the smallest countries on the continent, Rwanda's total area is estimated to be KM^2 26,338. According to Rwanda's National Institute of Statistics (NISR, 2017), in 2015, the population density in Rwanda was estimated to be 445 people per KM^2 and the total population is approximately 11,809,295 according to 2017 NISR projection. According to official statistics, the poverty rate in Rwanda decreased from 58.9% of the population in 2000/2001 to 38.2% in 2016/2017 (using the national poverty line).

Nevertheless, over one third of people are still below the poverty line and 16% are classed as extreme poor. Poverty rates are higher in rural areas than in urban areas at the national poverty line. The 43.7% of people in rural areas are poor and 18.1% are extreme poor compared to a 15.8% poverty rate and 5.8% extreme poverty rate in urban areas (NISR, 2017). This study recalled the purpose of the community self-help initiatives through the replication of successes, which is community sustainable livelihoods development by accelerating the pace of developing such that the people themselves assert their economic, social, and cultural conditions maintaining the balance in concerned community ecosystem matching with SDG-1 (no poverty), SDG-2 (zero hunger), and SDG-3 (good health and well-being) (Rondinelli and Mandel, 1981).

Whereas community self-help initiatives through success replication scheme for the development purpose are defined and conceptualized variously, and its modes of operation are made up of three essential elements: (i) the participation by the people, (ii) initiative self-help by the people, and (iii) strengthening the community as an entity (Adedayo *et al.* 1991). Community Self-

help is an attempt to reduce poverty and satisfying basic needs by involving locals through replication of successes. In order to make this study more comprehensive, the researcher employed three connotations such as community initiatives, sharing of achievements and replication of success.

2. Problem statement

Rural areas differ markedly in their development experience, economic structure, natural and human endowments, geographical location, demographic and social conditions. Therefore, they are affected in different ways, and to differing extents, by socio-economic and policy changes shaping the national and economic environment” (OECD, 1998: 15). Extreme poverty is mainly a rural phenomenon. Four of every five people below the \$1.90-a-day international income poverty line lived in rural areas (Castañeda, 2018). Agenda 2030 relies on 17 sustainable development goals and 169 targets supported by the United Nations as a global effort to manage current challenges related to poverty, climate, environmental pollution, geographical inequalities, prosperity, peace, and justice. Rural changes of the economic sources of livelihoods may accompany innovational changes or changes in habitats, family systems or relationships between humans and nature (Rauch, Beck-mann, Neubert, Rettberg, 2016).

There has recently been increasing interest in the Socio-economic relationship between rural households and environmental resources (Cavendish 2000; Fisher 2004; Vedeldet *al.* 2004). It has been shown that rural households depend quite heavily on freely-provided environmental goods and services to sustain their welfare, through the provision of both productive inputs and consumption goods. Poverty in rural communities of Rwanda will

not decline without growth in rural incomes, and rural incomes will not grow without reducing inequalities among communities, and this will not be achieved unless there is a fair share of outcomes just for an effective less dependency on external aids. Most external help actually overrides or undercuts the budding capacity for self-help and thus ends up being unhelpful (Gronemeyer, 1992).

Perhaps the best even the only effective slogan for aid is find out what the people are trying to do and help them to do it better (Schumacher, 1964). The big concern is that, all aids are based on the simple working assumption that the condition of needing aid was externally imposed and the aid recipients share no responsibilities. However, over the course of time, such aid tends to undermine this assumption, as the aid in effect becomes a reward for staying in the state of needing aid (Murray, 1984). All this creates dependency and learned helplessness. With this, the concept of Community Self-Help, replication of successes and sharing of achievements gained prominence in various parts of the world (Ellwood, 1988). According to the United Nations, the ambitions of the global Sustainable Development Goals (SDGs) are to put people “at the centre of sustainable development and strive for a world that is just, equitable and inclusive” (UN 2015). It connotes that the people themselves assert their economic, social, and cultural conditions. It involves all the members of the community and requires their fullest participation in first making and then implementing decision for their well-being and development. The 2 main questions were identified as triggers to conduct this study “how can Rwanda be able to end such extreme poverty alongside with the achievement of sustainable development? And how rural communities ‘livelihoods are in relationship with environment? Alongside with these questions,

the researcher attempted to examine how the replication of success can sustain rural livelihoods development with inclusive innovation in Rwanda.

3. Objective of the study

In this study, two objectives were targeted namely general and specific objectives

3.1 General Objective

The general objective of this study was to examine the replication of success for sustainable rural livelihoods development with inclusive innovation in Rwanda.

3.2 Specific objectives

- i. To determine the features of replication of success among neighboring communities in Ngeruka Sector
- ii. To examine the types of channels for replication of success among neighboring communities in Ngeruka Sector
- iii. To assess the extent to which the replication of success sustains the neighboring communities' livelihoods in Ngeruka Sector
- iv. To determine the moderating effects of replication of success among neighboring communities in Ngeruka Sector

4. Literature review

In this section, the researcher intended to discuss the 6 types of theories associated with the study. Those included the Human Capital Theory, Social Capital Theory, Physical and financial capital Theory, Reciprocity theory, Theory of the gift (Gift relationship Theory) and Social Support Theory.

4.1 Human Capital Theory

Human capital theory in this study referred to the transmission of knowledge, education, and work competence among communities; however, thus community facilitators were considered as productive assets not costly assets (Hendricks, 2002).

4.2 Social Capital Theory

Bourdieu (1986) defines social capital as ‘social connections, mutual acquaintance and social recognition’. Coleman (1988) indicates all those features of the social structure that might facilitate actions of individuals within the social structure itself. Social capital is about the value of social networks, bonding with similar people and bridging between diverse people, with norms of reciprocity (Dekker and Uslaner 2001). Thus, social capital can be considered as the stock of active connections among individuals: the trust, mutual understanding, and shared values and behaviors that bind the members of human networks and make possible cooperative action (Cohen and Prusak 2001).

4.3 Physical and Financial Capital Theory

This theory suggests that people with enough Physical and Financial capacity have added value in acquiring resources to

efficiently exploit the entrepreneurial opportunities (Clausen, 2006). Physical and Financial capital are the apparatus used to produce a good and service. Physical and Financial capital represent the tangible man made goods that help and support the production.

4.4 Reciprocity theory

The study was developed under three degrees of reciprocity: generalized, balanced and negative (Sahlins 1968, Service 1966). With generalized reciprocity, someone gives to another person and expects nothings concrete or immediate in return (Harris, 1974). People routinely share with other band members (David, 1992 and Kent, 1992). Generalized reciprocity through Rwandan proverbs can be as: *Uzangayireguhera, ntuzangayiregutinda*. Agafunikabagaraubucutin'akarenge... Here, the delay to return the gift is not determined. Balanced reciprocity applies to exchanges whereby the giver expects something in return (Sahlins, 1972).

This may not come immediately, but the social relationship will be strained if there is no reciprocation. Balanced reciprocity through Rwandan proverbs as: *Akebo kajya iwamugarura, Agasozi kazamutse inka kamanuka umugeni or kamanuka iyindi, Ha uguha* (Inumay'i Burundi ibwira iy'i Rwanda). Negative reciprocity occurs when an action that has a negative effect on someone is returned with an action that has an approximately equal negative effect (*Caliendo, et al., 2012*).

4.5 Agonistic Exchange Theory: Gift relationship

Marcel MAUSS (1923) analyzed the agonistic as exchange in which ceremonial values transcend economic values in order to gain social status and prestige. According to him, a gift in nonindustrial traditional societies supposes 3 obligations: to give, to receive, and to return what one has received. Marshall Sahlins (1972) argues that competition between partners fight against each other, not by using weapons, but items (goods and services), in order to acquire honor, social consideration, social prestige, and thus to increase or improve one's social status and that of his group.

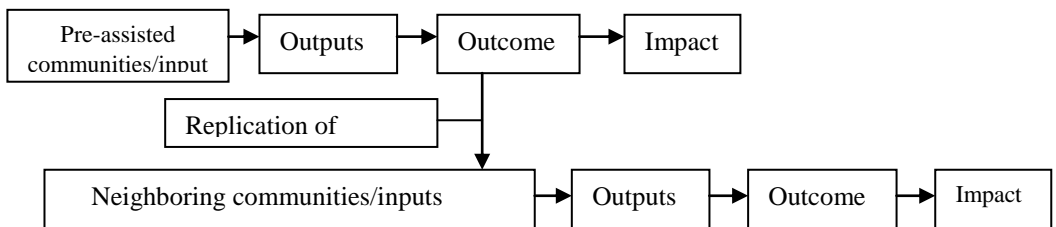
4.6 Social Support Theory

Social support is commonly conceptualized as the social resources on which an individual can rely when dealing with life problems and stressors (Thoits, 1995). Elaborating on this idea, Cullen, Wright, and Chamlin (1999) described social support as a process of transmitting human, cultural, material, and social capital, whether between individuals or between larger social units (communities, states) and their members. Support is often provided informally, through social relationships, but support can also be provided formally by an entity with an official status, such as government assistance programs or the justice system. Social support has direct and indirect effects on delinquency and other indicators of well-being. As a direct effect, people who experience social support may engage in less delinquency. As an indirect effect, social support may act as a buffer between risk factors for delinquency and participation in delinquent behavior. Social support has several dimensions (Thoits, 2011).

First, support can be conceptualized as perceived, feeling supported or feeling that support is available, versus received, reporting that assistance was provided. Second, support can be instrumental, informational, or emotional in nature. Instrumental support refers to the provision of materials or assistance with practical tasks or problems, such as lending money or borrowing a car. Informational support refers to advice giving, guidance, or providing information that may help a person solve a problem. Emotional support involves the expression of sympathy, caring, esteem, value, or encouragement. Third, social support can be distinguished by its source. Members of an individual’s primary group, significant others such as family members and friends are frequently considered sources of support. Individuals may also draw support from their secondary groups, in which relationships are more regulated or hierarchical and less personal, such as schools and religious organizations.

The most important sources of support, the level of support in a relationship, and the impact of support on behaviors vary over the life course (Umberson, Crosnoe, and Reczek, 2010).

5. Conceptual framework



**Figure 1: Conceptual framework,
Source: Own construction**

6. Empirical studies

Different types of capitals have been considered as inputs, which enter the process of replicating goods and services among neighboring communities (Menzie, 2003). Human capital plays an important role in people's development, improving the life and income, increasing knowledge, skill, and product capacities, economic growth and reducing poverty. It has been asserted by Hawkes and Ugur (2012) that investing in education and skills has long been considered a key driver of economic development of communities. For example, Zhao (2008) considers investment into human capital through education and training as key to national socio-economic development. Considering social capital as a productive factor, Heller (1996), Ostrom (2000) and Rose (2000) point out that social capital contributes to economic growth by facilitating collaboration between individual interests towards the achievement of increased output. The social capital promotes the community's welfare and directly affects the efficiency of goods and services. For example, the high level of trusteeship in the society increases the costs of network transactions (Rastogi, 2002). The survival of communities depends on their power of rebuilding

7. Data collection

The data underlying this study were collected within 10 months of fieldwork (*November 2020 - August 2021*) in 12 villages of Ngeruka sector in Bugesera District- Eastern Province. The qualitative and quantitative data were collected using 300 community member-based questionnaires, administered in the local language by a team of 12 local enumerators. The questionnaire used contained questions related to human, physical

and social capitals, sustainable rural livelihoods development as well moderating effects.

Due to the nature of the study, it required for data to be collected after each term. Apart from questionnaires, the 12 Focus Group Discussions were also conducted to 24 groups included the 12 pre-assisted groups while other 12 referred to the recipients of successes. In the absence of an official census, a household register was compiled consisting of 3,170 community members (in neighboring communities).

According to the nature and aim of the study, the selection was based on the level of people's vulnerability and the 800 most vulnerable people were identified in the neighboring communities. The selection criteria consisted of widows, widower, single mothers, women headed households, people living with disabilities, child headed households, people with chronic disease, people experienced sexual gender based violence and those ranked the first category of poor living conditions (1st category of Ubudehe). Among such 800 most vulnerable people, the 300 were randomly selected among others to participate in the study. The participants to whom the questionnaires were addressed corresponded to 293 while other 7 were interviewed. To collect field data, the participatory technique was also used. Participatory research aimed to work closely with targeted community members. There was often an assumption that local communities existed as distinct entities: small, well-bounded, and homogeneous and integrated (Schwartz, 1981).

The four modes of participation were taken into account including contractual technique whereby people were contracted into the project to take part in their enquiries or experiments. The 2nd mode was a consultative technique by which people were asked

for their opinions and consulted by researchers before interventions were made while in the collaborative technique, the researcher and local people worked together on project, initiated and managed by the researcher and lastly, the collegiate technique, the researcher and local people worked together as colleagues with different skills to offer, in a process of mutual learning where local people had control over the process (Biggs, 1989). Within these needs, values, sentiments and ideologies were shared. For the researcher to work together with community members as participants in research enabled to enhance the effectiveness of the study and to save time and money (Chambers, 1992).

8. Presentation of data and discussions

With this section, the researcher intended to discuss the four specific objectives of the study as related to discovering the features of replication of success, examining the types of channels for replication of success, assessing the extent to which the replication of success sustained the neighboring communities and determining the moderating effects of replication of successes.

8.1 Distribution of respondents with their respective communities

The following tables indicated the number of participants to which the study was conducted respectively with their villages of resident and names groups to which they belonged.

Table 1: First round distribution of respondents for Focus Group Discussions

S/N	Pre-assisted communities	Groups	Number of members
1	NYAKAYENZI	TUBUMWE	25
		TERIMBERE MUGORE	25
2	KARAMA	URUHARE MW'ITERAMBERE	25
		TERIMBERE MUBYEYI	25
3	TWIMPARA	DUHARANIRE KWITEZIMBERE	25
		TWISUNGANE	25
4	KAMUGERA	NEZERWA IWACU	25
		EJO HEZA	25
5	KABUMBWE	ABITEZIMBERE	25
		ABISHYZEHAMWE	25
6	RUBIRIZI	ABADAHWEMA	25
		ABADAHEMUKA	25
	TOTAL		300

Source: Field data, November 2020 - August 2021

The first 6 communities composed of 300 people (Table 1; 193 females and 107 males) consisted of the pre-assisted communities while the 2nd (Table 2) made up of 208 females and 92 males were the recipients of successes. The first communities were named pre-assisted to mean they were supported by a certain Local Non-Governmental Organization via a livelihood project aimed at improving their well-being through the increase of food and income security, gender equality and resilience to climate change. During the project implementation, the beneficiaries were assisted and trained how they would share their achievements to other needy neighboring communities. To do this, after 3 years of the project implementation, other 6 neighboring communities were

identified among others and the replication of success was applied to them thanks to the first communities' successes.

8.2 Features of replication of success among neighboring communities

This section intended to target the 1st specific objective of the study in which the features of replication of success were discussed. Such features consisted of human, physical and social capitals and how they were replicated from the successful assisted communities to the neighboring vulnerable communities. The section explicated also about the period of time the replication of success might last.

Table3: Distribution of respondents about features of replication of success among neighboring communities

Pass-on of human capital /Soft and practical skills	Number of Community Trainers (n=300)	Percent	Neighboring Trainees (Frequency)	Percent
Livestock management and Treatment	12	4.0	300	100.0
Modern agricultural techniques	12	4.0	285	95.0
Micro-credit and micro-business	12	4.0	300	100.0
Cooperative management	6	2.0	85	28.3
Sexual Gender Based Violence	6	2.0	140	46.6
Disaster management	6	2.0	300	100.0
Conflicts management	6	2.0	91	30.3
Total	60	20%		
Pass-on of Physical capital	Givers (Frequency)	Percent	Receivers (Frequency)	Percent
Livestock (female goats)	236	78.7	236	78.7

Seeds (maize, g-nuts, beans, sorghum)	281	93.7	281	93.7
Income (Village Saving & Loan Associations)	248	82.6	300	100.0

Source: Field data, November2020 - August 2021

In order to gather information, the reference was made to 300 beneficiaries of a certain project from 6 communities (villages) and other 300 neighboring community members from other 6 villages.

The table above describes how the local communities provided assistance to other neighboring poor communities. Their supports were based on their achievements over the four years (2016-2019) they have received from the external aids or project. Out of 300 targeted community members, the 20% of them were selected among others and received trainings in various domains including livestock management and treatment, modern methods of farming, micro-credit and micro-business, cooperative management, Sexual gender-based violence, disaster and conflict management. After being trained on the above mentioned subjects, the trainees were identified as community facilitators respectively entitled as paravets, lead farmers, VSLAs leaders, Cooperative leaders, gender champions, Disaster Risk management Committee, local community mediators or conflict resolution facilitator. These were supposed to transmit soft and practical skills to other 300 neighboring community members. After four years, these 300new trainees will also select among themselves other members who will be specially trained and thus impart knowledge to other people in the same way. Davenport and Prusac (1998) define knowledge sharing as “people who

apply societal knowledge by utilizing knowledge already present in the community.”

In accordance with Cummings (2004), Pulakos, Dorsey and Borman (2003) knowledge sharing refers to the provision of task information to support collaboration with the purpose of solving issues, expand new concepts, or implementing practices and procedures. Numerous societal assets can be acquired by knowledge sharing, such as a community’s accomplishments and innovation (Collins and Smith, 2006), competitiveness (Argote and Ingram, 2000), faster product development and lower production costs (Lin, 2007; Hansen, 2002). Other advantages include knowledge appliance and competitive advantages for the community (Berman, Down and Hill, 2002; Jackson, Chuang, Harden and Jiang, 2006). In a professional context, sharing knowledge highly relied on shaped understandings of individuals on knowledge sharing as well as the depth and width of their network (Cabrera & Cabrera, 2005). This was also linked to innovation, which, according to Kreiner and Schultz (1993) emerged from communities' relationships with and membership in internal and external communities, where they acquired and absorbed new knowledge and deepen existing knowledge.

In addition to the knowledge provided by community facilitators, the beneficiaries were also involved in supporting other poor neighbors with some of their achievements whereby the study mentioned the 78% people who passed-on female goats, 93.7% who donated maize, ground-nuts and beans while 82.6% grouped into savings and loan groups passed on the same amount of given funds to other new neighboring groups. The beneficiaries were

given 2 female goats by the project and were requested to donate 2 new born female goats to other needy neighbors and this was also practiced to seeds by which they were asked to provide to others the same quantity of seeds they were supported with.

8.3 The channels for replication of success

The study examined the types of channels that enabled to replicate successes among the targeted communities. This was the 2nd specific objective of the study. By referring to table 3, the researcher was impressed to understand how human, physical and social capitals linked to one another and how they were collaborative to ensure the replication of success and this was identified as the “reciprocity”. During the analysis, the three types of reciprocities were discussed namely generalized, balanced and negative reciprocity.

Table4: Demonstration about channels for replication of success

Pass-on of human capital / Soft and practical skills	Reciprocity
Livestock management and Treatment	Generalised
Modern agricultural techniques	Generalised
Micro-credit and micro-business	Generalised
Cooperative management	Generalised
Sexual Gender Based Violence	Generalised
Disaster management	Generalised
Conflicts management	Generalised
Pass-on of Physical capital	Reciprocity
Livestock (female goats)	Balanced and generalised
Seeds (maize, g-nuts, beans, sorghum)	Balanced and generalised
Income (Village Saving & Loan Associations)	Balanced and generalised
Social capital	Reciprocity
Values	Balanced
networks	Balanced
Respect and trust	Balanced
Recognition and identity	Balanced
Services	Reciprocity
Treatment of livestock by paravets	Negative
Joining existing cooperative	Negative

Source: Field data, November2020 - August 2021

The study identified three channels through which the replication of success was applied. The models as shown in the table were used in a complementary or independently way. The first method was to select the achievements that were supposed to be given to the vulnerable communities but the donors did not intend that the

donations will be returned to them (generalised reciprocity). For instance, the dissemination of skills or other mobilization campaigns provided by the community trainers; the trainees were never requested to pay for any compensation in order to attend the training sessions; this approach worked independently (Harris, 1974).

Secondly, the transfer of results from some communities to others was done and after a certain period of time the recipients passed-on a part of their successes to other people in needy and so forth. These people who were provided with achievements by others were also sensitized and encouraged to donate part of materials towards their neighbors after inquiring that there were significant achievements to them. Here, the study indicated how the pre-assisted communities who were given female goats, seeds (beans, g-nuts and maize) and funds through Village Saving and Loan Associations to run small businesses have also passed-on the same quantity of given supports to other people in needy. The study explicated that even though the giver received nothing from the recipient but the later was supposed to pass-on a part of success to other vulnerable neighbors and the approach was called “balance and generalized reciprocity” (Harris, 1974, Fleisher 2000). The combination of two channels (balanced + generalised) resulted from the fact that, the giver expected nothing from the recipient however the later must have passed-on success to other vulnerable ones. The last method used to replicate success among neighboring communities was based on the fact that people who were offered with services had something to give immediately to the donor. A typical example was identified to the community

members who were previously trained on livestock treatment; these were identified in the community as “paravets”. They provided livestock treatment services and a certain small amount of money was charged.

Unless there was an agreement between the service provider and the beneficiary, but this method provided that the service must be paid immediately however the cost of the service was somehow lower because the approach considered this as a mutual support between the members of the community otherwise the approach was named “negative reciprocity” (*Caliendo, et al., 2012*). Another fact was seen to the people who joined cooperatives as new members but they required paying a share and it was the same as seed storing; when they stored seeds in the seed banks they were supposed to pay the security fees the security fees to the cooperative.

8.4 Extent of replication of success for Sustainable community’s livelihoods

The 3rd Specific objective was discussed in this sub-section. The aim of this part was to reveal how the replication of success sustained the neighboring communities of Ngeruka sector who were just as recipients of successes generated by the pre-assisted communities. All targeted community members (300) including 219 females and 81 males were taken into consideration in providing data. Here, the major indicators were discussed in the table below:

Table5: Distribution of respondents about the extent of replication of success

S/N	Indicators	Frequency n=300	Percent
1	Accessed to basic needs		
	At least 2 meals a day	292	97.3
	Paid school fees for children	218	72.6
	Paid medical insurance	284	94.6
	Rebuilt or built a new house	32	10.6
	Built rain water tank	11	3.6
	Electrified a house	13	4.3
2	Household conflict reduced	101	33.6
3	Willingness to stay in the community increased	191	63.6
4	At least 1/2 of own land is used	230	76.6
5	Sources of income diversified	193	64.3
6	Dependency rate reduced	185	61.6
7	Purchased more land	22	7.3
8	Able to take decisions at the community level	56	18.6
9	Livestock production increased	203	67.3
10	Agricultural production increased	241	80.3
11	Accessed to micro-financial institutions	37	12.3

Source: Field data, November2020 - August 2021

The study demonstrated how the economy and achievements were better shared among the communities towards inequality reduction purpose; that sharing community achievements made it

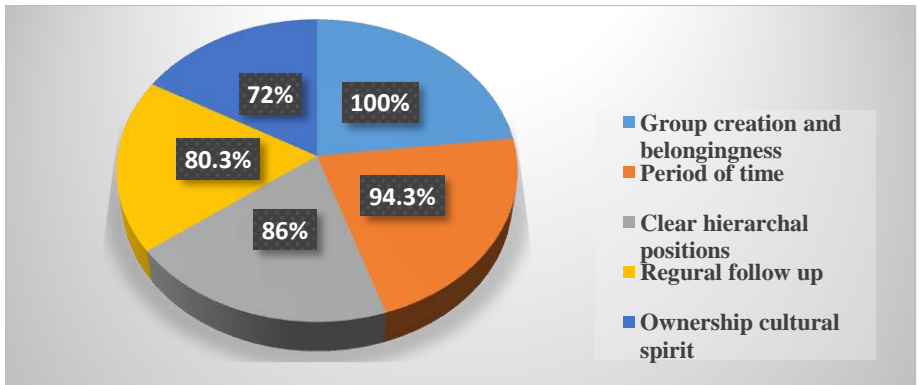
possible for a large number of people to have access to basic household needs such as getting meals more often, being able to afford medical care and paying for children's education as approved respectively by 97.3, 72.6 and 94.6 %.

It was seen that, this approach helped to reduce and combat conflict among households as resulted from poor living conditions (33.6%) and reduced the culture of dependence on external or foreign donors or to remain a burden on the government with 61.7% of respondents affirmed. Not only that, but this study has also shown that, the real development is the one in which communities can express their full potential where they can find the most basic solutions to the problems they face and communities themselves have achieved many that they could not achieve if they continued to lay hands on the government or on foreign aid. The study explained on how the mutual support among the communities themselves was a good way to keep them from migrating to other parts of the country for searching for lives, rather enabled them maintaining their community (63.6%).In addition, infrastructures and other natural resources were sustainably managed; for example, the people were able to use their resources wisely and make them productive such as land (76.6%), water with 3.6%, livestock (67.3%) and money with 64.3%.

8.5 Moderating effects of success replication among neighboring communities in Ngeruka sector

The section comes to reveal the relationship between replication of success and its impact. This is shown by testing the moderating effects via a number of measurements as shown below:

Figure: 1 Distribution of respondents on the moderating effects



Source: Field data, November2020 - August 2021

The study identified a number of moderating effects that motivated the replication of success amongst the neighboring communities in Ngeruka sector and those included the community structure which consist of breaking down beneficiaries into small groups to easy the communication and all beneficiaries belong to such groups. This enables also to conduct the regular follow-up as confirmed by 80.3 % of respondents. The replication of success requires enough time for the concerned people to prepare themselves as confirmed by 94.3 percent of beneficiaries. It concerned the forth specific objective of the study. It argued that by implementing a less centralized community structure, replication of success was simplified (Kim and Lee, 2006). It was

important for communities, to create opportunities for communication across groups via clear positions and hierarchy (86%) (Yang and Chen, 2007). The study detected two key elements that supported the replication of success or sharing of achievements: a structure encouraging the flow of communication between groups or units and establishment of leading committees at a level that made it not too difficult to share and practicing a realistic approach that was comprehensible (Hashimet *al.*, 2016). In case a social collaboration platform was unsupervised, the replication of success could not be guaranteed. The study depicted that; sources needed to be reliable to be used by the communities (Vargoet *al.*, 2003).

It was argued, that monitoring and evaluation of the approach enriched the quality and raised expectations. The study has shown that, in order for communities to work together and develop in a sustainable way, there was appropriate and sufficient period of time for pre-assisted communities to make sure they were truly evolving. Simply put, it was easy to measure the time limit for replication of success from best community towards the needy ones, because it depended on the size of their achievements and what they were able to achieve by referring to the baseline. The study argued that although the early communities provided assistance to other poor communities after four years, it did not mean that the 4-year period was a norm or principle, but that it could go down or up depending on the extent of monitoring or follow up to the concerned communities. Well-monitored communities started replicating successes in a real planned time or little bit before.

A typical example of this study was that the pre-assisted communities began to help other vulnerable communities at the

same time as planned; and these second-round communities have also begun to show their willingness to help other poor communities as they have begun to show good achievements. For example, the first saving and loan groups have begun to support other groups after only one year of assistance. The support provided by such groups consisted of the funds known as start-up capital for income generating activities. This approach of sharing achievements among communities has no end; it is said to be unlimited when employed properly with an effective follow-up.

9. *Conclusion and recommendations*

The study has shown the worth of replication of outcomes among communities. This approach has helped the communities to help themselves and reduce reliance on external funding or to remain a burden on the government. People working together as communities through the replication of success can act both locally and globally (Westoby and Dowling, 2013). The process covered the sustainable rural livelihoods development and social change need, to insure the balance of activities and resources. It demanded to enable spaces for collective action to emerge and helping community-based initiatives to connect to one another directly (Howard and Wheeler 2015). Human, physical and social capitals were identified as both inputs and outputs to be replicated. The channels through which replication of success was done were generalized, balanced and negative reciprocity and worked either independently or collectively according to the type of material to be replicated. Communities to which replication of successes was applied were able to meet the basic needs and became champions to the conservation of the environment under the efficient use of resources both natural and artificial.

This approach identified itself as the only way to help communities cope with their problems and be able to find lasting solutions. Empowering communities as well as giving them opportunity to make decision have increased their motivation and reduce their resistance to community changes (Thomas *et al.*, 1996). The study encouraged public, private and non-governmental organizations to take advantages on the applicability of replication of success towards the community resilience and sustainable livelihoods development. All concerned organizations are recalled to help communities bearing the culture of ownership spirit as the real pathway for the replication of success to take place. The findings of this study are highly privileged to recommend the government of Rwanda to adopt the replication of success related policy among others.

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**AN EVALUATION OF FINANCIAL
LITERACY AMONG BUSINESS OWNERS
OF MICRO, SMALL AND MEDIUM
ENTERPRISES IN RWANDA**

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ABSTRACT

This paper is an evaluation of financial literacy among business owners of Micro, Small and Medium Enterprises in Rwanda. The objectives of the study were to determine: Levels of financial knowledge; levels of financial skills; nature of attitude towards financial matters and nature of financial behaviour. The study is hypothesized on the fact that a combination of high financial knowledge level, high financial skill level, good financial behaviour and positive attitude towards financial matters results in high level of financial literacy. The study employed a cross-sectional survey design covering 200 participants. This sample was determined using Sloven's formula. Data was collected using a questionnaire and analyzed using MS Excel. The key findings were that 72.7% of micro business owners have a high financial knowledge level, 77.7% have a high skill level, 69.3% have good attitude towards financial matters and 69.7% were practicing good financial behaviour. Also, 73.7% of small business owners have high financial knowledge, 79.5% are skilled in financial matters, 71.0% have good attitude towards financial matters and 76.2% were practicing good financial behaviour. Other findings are that 85.5% of the medium business owners have high financial knowledge level, 87.8% have high financial skill level, 73.7% have good attitude towards financial matters and 77.1% were exhibiting good financial behaviour. The study recommends that the government should identify the 13.5% of micro business owners, the 15.1% of small business owners and the 9.8% of medium business owners who are not knowledgeable and educated them on financial matters so that they also become knowledgeable; identify the 9.4% of micro business owners, 9.9%

of small business owners and 6.4% of the medium business owners who are not skilled, and train them in appropriate financial skills so that they become adequately skilled; identify the 19.7% of the micro business owners, the 19.7% of small business owners and the 20.9% of the medium business owners who have poor attitude towards financial matters, and then sensitize them so as to change their mind set for them to adopt a good attitude; identify the 18.5% of the micro business owners, the 14.2% of the small business owners and the 16.4% of the medium business owners who practice bad financial behaviour and then educate them on good financial behaviour.

Key words: Financial literacy, Knowledge, Skills, Attitude, Behaviour, Enterprise

1. Introduction

Background

Definitions of Financial literacy vary depending on the study field, expertise and field of interest of the person who formulates the definition. Murat Y, Fatih B, Ahmet O & Gulay G. (2017) observe that 71 studies attempt to define the concept of financial literacy and that the term has been assigned eight different meanings. Some studies handle financial literacy completely within the context of general knowledge on financial issues while others emphasize the multidimensional nature of financial literacy, both the knowledge and experience related aspects, the ability to be self-confident when making financial decisions and the competence to make financial decisions.

In simple terms, financial literacy refers to an individual's ability to use and manage financial resources effectively and to use knowledge and skills to ensure a lifetime financial well-being. The OECD INFE (2011) defines financial literacy as a combination of awareness, knowledge, skill, attitude and behaviour necessary to make sound financial decisions and ultimately achieve individual financial well-being. On the other hand, Simon Starček and Aleš Trunk (2015) define financial literacy as a combination of being aware of, knowledge, skills, behaviour that is necessary for a suitable financial decision and to reach its own financial wealth. By the most basic definition, Lereko Rasoaisi and Kalebe M. Kalebe (2015) explain that financial literacy refers to the knowledge and or understanding of the importance of money and the use of money.

Past studies (Sanjib Das 2016; Murat Y, Fatih B, Ahmet O & Gulay G. 2017) indicate that financial literate individuals have mathematical literacy, can effectively manage with money, and know how to manage a credit and debts. They are able to evaluate the need for insurance and protection. They know how to evaluate different kinds of risks and repayments that are connected to different possibilities of saving money and deposits. They also understand wide ethical, social, political and environmental dimensions of finances.

Rwanda's situation

According to the Financial Capabilities Survey (2012), Rwanda's population has low levels of financial capability. The survey

indicates that less than half of Rwandans do budget for their finances. Running short of money is common, mostly due to poverty or employment status. Rwandans tend to rely on mutual support and informal credit when short of money. Although most Rwandans understand the importance of planning for the future and feel a sense of personal responsibility for doing so, surprisingly more than half do not know enough about how to develop a financial plan.

The survey (Fin Cap Survey, 2012) further indicates that 60% of Rwandans save only if they have money left after their expenses. More than half Rwandans do not have a plan in place to manage a major unexpected expense that they might face tomorrow. About half Rwandans feel out of control with their borrowing and debt, and have varying degrees of knowledge of different financial service. Only 23% (Fin Cap Survey, 2012) of the people are knowledgeable about how to choose a financial product or service provider and half of Rwandans save or invest in the form of non-financial assets. Because financial literacy is a function of financial knowledge, skill, behaviour and attitude towards financial matters, the above statistical data prompted the research.

Study objectives

In conducting the research, the objectives were to determine:

1. Levels of financial knowledge
2. Levels of financial skills
3. Nature of attitude towards financial matters
4. Nature of financial behaviour

Research questions

The study was conducted in order to find answers to the following questions:

1. What is the level of financial knowledge among business owners of micro, small and medium scale enterprises in Rwanda?
2. What is the level of financial skill among business owners of micro, small and medium scale enterprises in Rwanda?
3. What sort of attitude do business owners of micro, small and medium enterprises in Rwanda have towards financial matters?
4. What is the nature of financial behaviour among business owners of micro, small and medium enterprises in Rwanda?

Study hypothesis

The study is hypothesized as follows:

‘A combination of high financial knowledge level, high financial skill level, good financial behaviour and a positive attitude towards financial matters results in high financial literacy level’.

Conceptual framework

The study was anchored on the fact that financial knowledge level, financial skill level, financial behaviour and attitudes towards financial matters collectively determine the overall level of financial literacy of a person. In this study therefore, the independent variables (the predictors) are knowledge, skills,

behaviour and attitudes. The dependent variable is financial literacy level.

In this study, financial knowledge level was evaluated in terms of knowledge about financial risks; costs associated with financial products and services; interest rates; basic financial terms; key features of financial products and services; benefits associated with financial products and services; inflation; taxation and taxes.

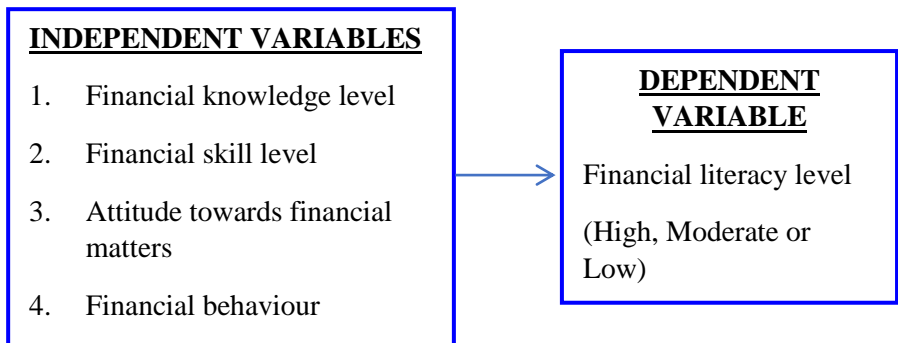
Financial skill level was evaluated in terms of ability to deal with banks; handle financial matters; plan sequences of financial activities; make personal budget; compute taxes; decide what financial services to choose; accurately determine benefits from financial dealings; accurately determine costs from financial dealings; wisely use financial resources; plan for future financial needs; compute interest rates and ability to keep simple financial records.

Attitude towards financial matters was evaluated in terms of willingness (or unwillingness)/being interested (or uninterested) in keeping financial records; making financial savings; spending money responsibly; interest in financial matters; dealing with financial institutions; sharing information about financial matters; interest in financial news; being organized in regard to managing money and payment of bills.

Financial behaviour was evaluated in consideration of a person's habit to always: read the terms and conditions on use of financial products/services; approach to saving money; approach to

spending money responsibly; keeping aside some money for future use; choosing financial products that suits his/her needs and conditions; timely repayment of money that is owed to others; spending by sticking to one's budgets; comparing prices before making choices on financial products/services; endeavouring to pay bills; keeping a close watch on one's personal financial affairs; having financial goals and having a concrete plan on how to achieve them; remaining responsible when it comes to money matters; gathering information before choosing a financial product; shopping around before making a choice on a financial product; objective borrowing to fund one's business expenditures; tracking one's spending and saving on regular basis.

Figure 1: Conceptual framework



2. Literature review

2.1 Financial literacy dimensions

Financial literacy has become important in developed and developing countries due to the fact that financial markets have grown and got more complex over the last decades due to globalization and financial instruments have been diversified. It depends on individuals' ability to increase their levels of financial literacy to avoid financial damages in their financial decisions (Gale, W.G. & Levine, R. 2011).

Many individuals are not able to do economic calculations or to understand the distinction between nominal and real value. They also do not have sufficient knowledge about such basic economic terms as basic risk diversification. In addition, they also need to be informed about such technical concepts as the differences between bonds and stocks, investment fund operations and primary asset pricing comparisons (Lusardi & Mitchell, 2014).

A range of studies into the issue have revealed that those who lack sufficient financial knowledge are not able to save duly for their retirement (Lusardi & Mitchell, 2014), use high-interest loans and experience debt problems (Mahdavi, M., & Horton, N. 2014), follow the financial advice of their family and friends and invest less in stocks (Van Rooij et al. 2011). Therefore, individuals require education in relation to a range of financial issues to meet their financial needs and increase their wealth (Gale & Levine, 2010; Lusardi & Mitchell, 2014).

Financial literacy helps individuals to improve their level of understanding of financial matters which enables them to process financial information and make informed decisions about personal finance (Puneet Bhushan and Yajulu Medury, 2014). Financial literacy is directly related to the well-being of individuals. Previous research suggests that those with low levels of financial literacy, faces problems with issues relating to personal finance such as savings, borrowings, investments, retirement planning etc.

According to Rwanda's National Financial Education Strategy – NFE (2013), Financial education can build the knowledge, skills and self-efficacy of Rwandans, so that they are better prepared to set and meet financial goals; plan ahead and make careful decisions about future spending and saving, particularly in anticipation of periods of low or irregular income.

In addition, financial education can help citizens develop strategies to protect against and manage risks; manage debt responsibly and effectively; identify and evaluate available financial services to determine if the services meet their needs; invest for retirement and diversify their assets and exercise their rights and responsibilities as consumers of financial services.

RBC Wealth Management (2018) explains 6 principles of financial literacy including budgeting one's money; considering and providing for taxation; borrowing when necessary and what you can appropriately repay; careful planning before making investments; investing to achieve one's goals; and preparing or planning one's estate.

A number of socio-economic and demographic variables influence a person's level of financial literacy. On the one hand, Lereko Rasoaisi and Kalebe M. Kalebe (2015) observe that a range of studies carried out on investigating variables that determine financial literacy discovered that age, level of education, gender, major of study, occupation, region, area of residence, race, wealth and ethnical background are important in explaining financial literacy.

On the other hand, Trizah Thara Mbarire and Abdullah Ibrahim Ali (2014) consider the determinants of financial literacy to be demographic variables (age, gender, level of education); socio-economic factors (occupational status and type, personal income and other wealth factors); and source of information and advice (formal and informal tools) on financial issues.

Previous studies carried out on the gender differences in determining the level of financial literacy indicate that males are more likely to be more financially literate than females (Trizah et al, 2014). Level of education is positively correlated with financial literacy. Studies have consistently shown that individuals with higher levels of education are the most likely to be financially literate.

In addition to that, Houston (2010) has shown that the correlation between literacy and education is present at the early stages of lifecycle. He has discovered that children of college graduates perform better on numerical test. Studies also found financial literacy to be negatively skewed with regards to age (Njehia, MilcahWanjiru, 2017).

Literacy level is low among the young, highest among middle-age respondents, and declines slightly at an advanced age of 61 or over. Also, low income levels are associated with low financial literacy levels, and Houston (2010) observed that individuals with longer labor experience are largely financially literate.

2.2 Measuring financial literacy level

Measuring financial literacy aims at determining one's ability to use knowledge and skills to manage financial resources effectively for a lifetime of financial well-being. The process of measuring financial literacy considers a number of dimensions. Sanjib Das (2016) considers these dimensions to be knowledge, skills, attitudes and behaviour necessary to make sound financial decisions, based on personal circumstances, to improve financial well-being.

This concurs with OECD INFE (2011) who argue that financial literacy stresses general behaviours, attitudes and knowledge that could be attained in a variety of ways.

Huston (2010) identifies one of the content areas used in measuring financial literacy as money basics (time value of money, purchasing power, personal financial accounting concepts). He also includes inter temporal transfers of resources between time periods, including both borrowing (i.e., bringing future resources into the present through the use of credit cards, consumer loans or mortgages).

He further mentions investing (i.e., saving present resources for future use through the use of saving accounts, stocks, bonds or mutual funds) as another area of content. The fourth content area is protecting resources (either through insurance products or other risk management techniques).

Literacy is basically a qualitative term and so is financial literacy. Therefore, most of the researchers have developed scales of their own to measure the level of financial literacy among the respondents. Sanjib Das (2016) argues that the financial literacy measurement approaches can be grouped into two categories, namely the Objective test approach and the Self-assessment approach.

Sanjib further explains that under the objective test technique, multiple choice questions are asked to answer in the questionnaire or interview schedule. Score for every respondent is computed on the basis of correct responses provided by them. And finally based on the score the overall financial literacy level is determined. In the self-assessment approach subjective questions on the basic concepts of financial literacy and numeracy are asked to judge financial literacy of the respondents.

This approach has not been gained popularity among the researchers, as it is observed that the respondents try to overestimate their financial knowledge and elicit positive financial attitude and behaviour. Under this approach, respondents

are asked to self-assess their financial ability, understanding and skills.

3. Methodology

3.1 Research design

The study employed a cross-sectional survey design to assess the levels of financial literacy among business owners of Micro, Small and Medium Enterprises in Rwanda. The design was used to assess the knowledge and skill levels; and the financial attitudes and behaviour of financial and business owners. Thus, this enables the researchers to generalize results for entire population.

3.2 Study population and sample size

The study targeted a population of 400 business owners operating MSMEs in Rwanda. The researcher used Sloven's formula to calculate a sample of 200 respondents who participated in the study as shown below:

$$n = N/1+(\alpha)^2 \dots \dots \dots (i)$$

where;

n = sample size;

N = target population;

α = 0.05 level of significance.

Thus, in the case whereby N = 400 and α = 0.05 level of significance:

$$n = 400/1 + 400(0.05)^2$$

$$n = 400 \div 1 + (400 * 0.0025)$$

$$n=400 \div 1+1$$

$$n=200$$

Two sampling techniques were employed in selecting the participants. Purposive sampling was used to ensure that the study includes business owners from both urban and rural areas; and those operating Micro, Small and Medium enterprises. Random sampling was applied in selecting participants from among each of the purposively selected category.

3.3 Data collection

Primary data was collected using a questionnaire that was administered to the participants. Data was collected upon financial literacy knowledge, financial literacy skills, business owners' attitudes towards financial matters and financial behaviours of the business owners. Secondary data was obtained through reviewing literature of past related studies.

3.4 Data analysis

Collected data was entered in a computer and processed according to respective ranking of responses (strongly agree, agree, not sure, disagree and strongly disagree), using Microsoft Excel spreadsheet to generate frequencies and percentages from which interpretation and analysis were made.

3.5 Reliability and Validity

Content validity index was used to test for validity of the questionnaire (CVI > 0.50 for both experts) and Cronbach alpha coefficient was used to test for reliability (Cronbach alpha >0.60 for all variables).

3.6 Ethical considerations

Research ethics direct that researchers have a responsibility to recognize and protect the rights and will of the participants. In this regard the researcher ensured not to cause any harm to the participants, and they were guaranteed with anonymity, confidentiality and disclosure. The researcher ensured voluntary participation and both the researcher and participants had to sign a consent before they participated in the study.

4. Results and Discussion

4.1 Results

The purpose of the study was to evaluate financial literacy among business owners of micro, small and medium scale enterprises in Rwanda. The study thus focused on knowledge and skill levels, attitudes towards financial matters and financial behaviour.

The study results are provided in Tables 1 to 4 below.

Table 1: Percentage responses regarding perceptions about financial knowledge

SA = Strongly agree, A = Agree, NS = Not sure, D = Disagree, SD = Strongly disagree

Financial knowledge measure	Micro business					Small business					Medium business				
	SA	A	NS	D	SD	SA	A	NS	D	SD	SA	A	NS	D	SD
Knowledgeable about financial risks	15.8	62.1	8.4	8.4	5.3	22.4	59.7	9.0	7.4	1.5	29.6	59.2	3.7	3.7	3.8
Knowledgeable about costs associated with financial products/ services	18.9	65.3	7.4	6.3	2.1	22.4	62.7	4.5	7.5	2.9	29.6	66.7	0	0	3.7
Can easily compute interest rates	11.6	57.9	12.6	11.6	6.3	28.4	58.2	8.9	3.0	1.5	51.9	40.7	0	0	7.4
Can easily understand simple financial terms	8.4	56.8	21	10.5	3.3	29.9	47.8	11.9	7.5	2.9	33.3	44.4	11.1	7.4	4
Knowledgeable about key features of financial products/ services	8.4	60.0	21.1	8.4	2.1	20.9	47.8	14.9	11.9	4.5	25.9	66.7	0	3.7	3.7
Can easily make wise financial decisions	14.7	67.4	8.4	9.5	0	25.4	53.7	10.4	6.0	4.5	33.3	48.1	11.1	3.7	3.8

Can easily deal with banks	18.9	49.5	10.5	15.8	5.3	22.4	32.8	16.4	20.9	7.5	29.6	48.1	7.4	11.1	3.8
Can easily use a bank account	38.9	53.7	2.1	3.2	2.1	43.3	46.3	0	3.0	7.4	63	25.9	3.7	3.7	3.7
Can easily handle financial matters	9.5	46.3	18.9	23.2	2.1	19.4	28.4	20.9	26.9	4.4	22.2	44.4	7.4	18.5	7.5
Can easily compare financial products and services	11.6	61.0	17.9	9.5	0	19.4	52.2	13.4	10.5	4.5	33.3	63	0	0	3.7
Can easily plan sequences of financial activities	12.6	65.3	16.8	3.2	2.1	19.4	46.3	11.9	19.4	3.0	30	51.9	11.1	4	4
Knowledgeable about benefits associated with financial products and services	9.5	71.6	8.4	9.5	1.0	20.9	68.6	3.0	3.0	4.5	18.5	70.4	3.7	3.7	3.7
Knowledgeable about inflation	11.6	37.9	25.3	23.1	2.1	20.9	38.8	19.4	14.9	6.0	18.5	63	3.7	7.4	7.4

Table 2: Percentage responses regarding perceptions about financial skills

SA = Strongly agree, A = Agree, NS = Not sure, D = Disagree, SD = Strongly disagree

Financial skill measure	Micro business					Small business					Medium business				
	SA	A	NS	D	SD	SA	A	NS	D	SD	SA	A	NS	D	SD
Has ability to prepare own budget	35.8	51.5	7.4	3.2	2.1	34.3	53.7	5.9	3.1	3.0	48.1	40.7	7.4	0	3.8
Has ability to decide what financial services to choose	15.8	68.4	7.4	5.3	3.1	26.9	52.2	14.9	3.0	3.0	44.4	48.1	3.8	0	3.7
Has ability to accurately determine benefits from financial dealings	12.6	68.5	12.6	4.2	2.1	13.4	64.2	10.4	6.0	6.0	44.4	44.4	3.7	3.7	3.8
Has ability to accurately determine costs from financial dealings	9.5	66.3	7.4	11.6	5.2	16.4	64.2	8.9	4.5	6.0	37.0	55.6	0	0	7.4
Is capable of evaluating the different financial products and services	7.4	57.9	21.0	11.6	2.1	13.4	62.7	14.9	4.5	4.5	25.9	63.0	7.4	0	3.7

Is capable of wisely using his/her financial resources	15.8	51.6	25.2	5.3	2.1	19.4	55.2	17.9	4.5	3.0	29.6	55.6	3.7	7.4	3.7
Has ability to plan for his/her future financial needs	16.8	67.4	11.6	3.2	1.0	16.4	61.2	6.0	11.9	4.5	40.7	37.0	14.8	3.7	3.8
Is financially capable of making good use of financial products/ services	10.5	65.3	14.7	7.4	2.1	17.9	61.2	6.0	8.9	6.0	37.0	51.9	3.7	3.7	3.7
Has the ability to manage his/her money	25.3	62.1	7.4	1.0	3.2	22.4	67.2	6.0	1.5	2.9	44.4	48.1	0	0	7.5
Has the ability to compute interest rates	22.1	52.6	6.3	11.6	7.4	26.9	53.7	10.4	4.5	4.5	59.3	29.6	7.4	0	3.7
Is capable of handling his/her future needs	13.7	57.9	21.0	2.1	5.3	14.9	56.7	14.9	10.5	3.0	37.0	44.4	11.1	3.7	3.8

Table 3: Percentage responses regarding perceptions about attitude towards financial matters

SA = Strongly agree, A = Agree, NS = Not sure, D = Disagree, SD = Strongly disagree

Financial attitude measure	Micro business					Small business					Medium business				
	SA	A	NS	D	SD	SA	A	NS	D	SD	SA	A	NS	D	SD
Has good attitude towards saving money	38.0	56.8	1.0	3.2	1.0	29.8	67.2	3.0	0	0	48.1	44.4	0	3.7	3.8
Has good attitude towards spending money responsibly	11.6	74.7	5.3	5.3	3.2	9.0	68.6	9.0	7.4	6.0	22.2	70.4	3.7	0	3.7
Finds it easy to save money	20.0	65.3	6.3	7.4	1.0	13.4	49.3	16.4	18.0	3.0	40.7	37.0	3.7	14.8	3.8
Business owner enjoys spending money	4.2	11.7	10.5	56.8	16.8	0	14.9	13.4	43.3	28.4	0	14.9	3.7	44.4	37.0
Is always organized in regard to managing money	23.2	61.0	8.4	3.2	4.2	20.9	70.1	1.5	3.0	4.5	29.6	63.0	3.7	0	3.7
Is always interested in financial matters	9.5	35.8	17.9	33.7	3.1	14.9	40.3	11.9	23.9	9.0	22.2	26.0	11.1	37.0	3.7
Always likes conversation about financial matters	9.5	49.5	16.8	22.1	2.1	11.9	67.2	9.0	7.5	4.4	29.6	40.8	3.7	22.2	3.7
Always gets	6.3	70.5	12.6	5.3	5.3	13.4	67.2	7.5	7.5	4.4	18.5	63.0	7.4	7.4	3.7

information about financial issues from friends															
Is always interested in financial news	16.8	67.4	6.3	7.4	2.1	19.4	70.1	6.0	1.5	3.0	33.3	59.3	0	0	7.4
Feels very interested in dealing with financial institutions	14.7	52.6	13.7	14.7	4.3	16.4	47.8	9.0	22.4	4.4	29.6	51.9	7.4	7.4	3.7
Has good attitude towards financial matters	8.4	54.7	22.2	10.5	4.2	12.0	58.2	14.9	11.9	3.0	22.2	44.4	14.8	14.8	3.8

Table 4: Percentage responses regarding perceptions about financial behaviour

SA = Strongly agree, A = Agree, NS = Not sure, D = Disagree, SD = Strongly disagree

Financial behaviour measure	Micro business					Small business					Medium business				
	SA	A	NS	D	SD	SA	A	NS	D	SD	SA	A	NS	D	SD
Always reads terms and conditions on use of financial products/services	17.9	41.0	22.1	11.7	5.3	23.9	53.7	11.9	6.0	4.5	44.5	40.7	11.1	0	3.7
Always looks to saving money	26.3	67.4	3.2	3.1	0	22.4	71.6	3.0	1.5	1.5	44.4	48.2	0	3.7	3.7
Always looks to spending money	2.1	10.5	4.2	55.8	27.4	1.5	14.9	9.0	55.2	19.4	0	11.1	7.4	51.9	29.6
Always keeps aside some money for future use	24.2	57.9	10.5	4.2	3.2	25.4	59.7	7.5	3.0	4.4	40.7	48.2	7.4	0	3.7
Always chooses financial products that suit his/her needs and conditions	13.7	57.9	18.9	5.3	4.2	20.9	58.2	9.0	6.0	5.9	25.9	59.3	7.4	3.7	3.7
Often has better spending behaviour	6.3	65.3	11.6	11.6	5.2	9.0	61.2	10.4	14.9	4.5	18.5	66.7	0	3.7	11.1
Always repays money he/she owes on time	13.7	69.5	7.4	5.2	4.2	19.4	58.2	11.9	7.5	3.0	25.9	51.9	7.4	11.1	3.7
Always spends by	9.5	52.1	12.6	10.5	5.3	9.0	61.2	17.9	7.5	4.4	18.5	55.6	14.8	3.7	7.4

sticking to his/her budgets															
Always compares prices before making choices on financial products/services	12.6	66.3	8.5	8.4	4.2	23.9	56.7	7.4	6.0	6.0	22.2	55.6	11.1	7.4	3.7
Always willing to pay bills	13.7	68.4	8.4	7.4	2.1	25.4	64.2	4.5	1.5	4.4	37.0	48.2	7.4	3.7	3.7
Always keeps a close watch on his/her business's own financial affairs	13.7	56.8	13.7	9.5	6.3	17.9	61.2	6.0	9.0	5.9	22.2	63.0	11.1	0	3.7
Always has financial goals and how to achieve them	18.9	67.3	5.3	4.3	4.2	23.9	65.7	1.5	4.4	4.5	33.3	59.3	0	3.7	3.7
Always responsible when it comes to money matters	16.8	63.2	8.4	7.4	4.2	22.4	55.2	7.4	12.0	3.0	25.9	59.3	0	7.4	7.4
Has been actively saving in the past years	20.0	64.2	5.3	8.3	4.2	28.4	56.7	4.5	6.0	4.4	22.2	70.4	3.7	0	3.7

Always gathers information before choosing a financial product	11.6	73.7	8.4	4.2	2.1	23.9	67.2	6.0	1.5	1.4	25.9	70.4	0	0	3.7
Always shops around before making a choice on a financial product	9.5	64.2	15.8	6.3	4.2	22.4	55.2	11.9	9.0	1.5	25.9	59.3	11.1	0	3.7
Always borrows to fund his/her business expenditures	5.3	26.3	18.9	27.4	22.1	3.0	61.2	17.9	7.4	4.5	3.7	14.8	11.1	48.2	22.2
Always tracks their spending	5.3	34.7	17.9	30.5	11.6	13.4	44.8	22.4	10.4	9.0	14.8	40.8	18.5	18.5	7.4
Always saves on regular basis	11.6	53.7	15.8	12.6	6.3	17.9	59.7	7.5	11.9	3.0	18.5	59.3	0	18.5	3.7
Is always in control of his/her financial situation	8.4	71.6	10.5	6.3	3.2	14.9	67.2	9.0	7.5	1.4	29.6	59.3	3.7	3.7	3.7

4.2 Discussion

4.2.1 Financial knowledge

On the issue of financial knowledge, the results indicate that on average 14.6% of micro business owners strongly agreed with statements used to measure financial knowledge, 58.1% agreed, 13.8% were not sure, 10.9% disagreed and 2.6% strongly disagreed. These figures show that aggregately 72.7% of the micro business owners believed that they were adequately knowledgeable about financial issues while 13.5% considered themselves not knowledgeable.

In the case of small business owners, results indicate that on average 24.2% strongly agreed, 49.5% agreed, 11.1% were not sure, 10.9% disagreed and 4.2% strongly disagreed with statements used to measure financial knowledge. These results shows that aggregately, 73.7% of small business owners considered themselves adequately knowledgeable about financial matters while 15.1% considered themselves not knowledgeable.

Regarding the medium business category, results indicate that on average 32.2% of the respondents strongly agreed, 53.3% agreed, 4.8% were not sure, 5.2% disagreed and 4.6% strongly disagreed with statements used to measure financial knowledge. These results indicate that aggregately, 85.5% of the medium business owners believed that they were adequately knowledgeable about financial matters while 9.8% considered themselves not knowledgeable.

4.2.2 Financial skill

On the issue of financial skill level, results show that on average 16.8% of the micro business owners strongly agreed, 60.9% agreed, 12.9% were not sure, 6.1% disagreed and 3.3% strongly disagreed with statements used to measure financial skill levels. These results suggest that aggregately, 77.7% of the business owners believed that they were adequately skilled in financial matters while 9.4% considered themselves not adequately skilled.

In the case of small business owners, results show that on average 20.2% strongly agreed, 59.3% agreed, 10.6% were not sure, 5.7% disagreed and 4.2% strongly disagreed with statements that were used to measure financial skill level. These results indicate that aggregately 79.5% believed that they were skilled in financial matters while 9.9% considered themselves not adequately skilled.

Regarding the medium business category, results indicate that on average 40.7% strongly agreed, 47.1% agreed, 5.7% were not sure, 2.0% disagreed and 4.4% strongly disagreed with statements that were used to measure financial skill levels among the business owners. These results show that aggregately, 87.8% of the medium business owners had a perception that they were adequately skilled about financial matters while 6.4% considered themselves not adequately skilled.

4.2.3 Attitude towards financial issues

On the issue of attitude, results show that on average 14.8% of the micro business owners strongly agreed, 54.5% agreed, 11.0% were not sure, 15.4% disagreed and 4.3% strongly disagreed with statements that were used to test for attitude towards financial matters. These results indicate that aggregately, 69.3% of the respondents had a positive/good attitude towards financial matters while 19.7% had a poor attitude.

In the case of small business category, 14.6% strongly agreed, 56.4% agreed, 9.2% were not sure, 13.3% disagreed, and 6.4% strongly disagreed with statements that were used to test for attitude towards financial matters. These results indicate that aggregately, 71.0% of the business owners believed that they had a good attitude towards financial matters while 19.7% considered themselves lacking a good attitude towards financial matters.

As for the medium business category, results show that on average 26.9% strongly agreed, 46.8% agreed, 5.4% were not sure, 13.8% disagreed and 7.1% strongly disagreed with statements that were used to test for attitude towards financial matters. The results therefore indicate that aggregately, 73.7% believed that they had a good attitude towards financial matters while 20.9% considered themselves lacking a good attitude with financial matters.

4.2.4 Financial behaviour

On the issue of financial behaviour, results show that in the case of micro businesses on average, 13.1% of business owners strongly agreed, 56.6% agreed, 11.4% were not sure, 12.0% disagreed and 6.5% strongly disagreed with statements that were used to study financial behaviour. These results indicate that aggregately, 69.7% believed that they were practicing a favourable financial behaviour, while 18.5% their financial behaviour was not favourable towards good business operation.

In the case of small businesses, the results show that on average 18.5% of the business owners strongly agreed, 57.7% agreed, 9.3% were not sure, 9.4% disagreed and 4.8% strongly disagreed with statements that were used to study financial behaviour. These results therefore indicate that aggregately, 76.2% believed that they were practicing favourable financial behaviour while 14.2% their financial behaviour was not considered favourable for good business operation.

As for the medium businesses, results show that on average 25.0% of the business owners strongly agreed, 52.1% agreed, 6.7% were not sure, 9.5% disagreed and 6.9% strongly disagreed with statements that were used to study financial behaviour. Accordingly, these results indicate that aggregately, 77.1% believed that they were exhibiting good financial behaviour while 16.4% their financial behaviour was not considered favourable for good business operation.

5. Conclusion and recommendations

5.1 Conclusion

The study focused on evaluating financial literacy among micro, small and medium business owners in Rwanda. It used financial knowledge, financial skill, attitude towards financial matters and financial behaviour to measure the financial literacy levels.

Basing on the outcome of the analysis of the results, the study concludes that 72.7% of micro business owners have a high financial knowledge level, 77.7% have a high skill level, 69.3% have good attitude towards financial matters and 69.7% were practicing good financial behaviour.

The study also concludes that 73.7% of small business owners have high financial knowledge, 79.5% are skilled in financial matters, 71.0% have good attitude towards financial matters and 76.2% were practicing good financial behaviour.

The study further concludes that 85.5% of the medium business owners have high financial knowledge level, 87.8% have high financial skill level, 73.7% have good attitude towards financial matters and 77.1% were exhibiting good financial behaviour.

5.2 Recommendations

The outcome of the study indicates that there are some business owners who lack financial knowledge, those that are not skilled in financial matters, those who have a poor attitude towards financial matters and those who practice bad financial behaviour.

The study therefore makes the following recommendations:

1. The government to use its relevant organs and resources to identify the 13.5% of micro business owners, the 15.1% of small business owners and the 9.8% of medium business owners who are the non-knowledgeable people and educated them on financial matters so that they also become knowledgeable.
2. The government should also identify the 9.4% of micro business owners, 9.9% of small business owners and 6.4% of the medium business owners who are not skilled, and train them in appropriate financial skills so that they become adequately skilled.
3. The government should further identify the 19.7% of the micro business owners, the 19.7% of small business owners and the 20.9% of the medium business owners who have poor attitude towards financial matters, and then sensitize them so as to change their mind set for them to adopt a good attitude.
4. In addition, the government should identify the 18.5% of the micro business owners, the 14.2% of the small business owners and the 16.4% of the medium business owners who practice bad financial behaviour and then educate them on good financial behaviour.

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