Predicting the effects of microcredit on women's empowerment in rural Bangladesh: using machine learning algorithms

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Article Info	ABSTRACT
	This study aimed to predict the impact of microcredit on women's empowerment in Bangladesh using machine learning (ML) algorithms. In rural Bangladesh, where microcredit programs are not significantly employed, data for the study was gathered through a survey. The study gathered data on a range of socioeconomic, demographic, and women's empowerment indicators. The Naive Bayes (NB), sequential minimal optimization (SMO), k-nearest neighbor (k-NN), decision tree (DT), and random forest (RF) ML techniques were used in the investigation. In terms of the prediction of women's empowerment, the findings indicated that all five algorithms performed well, with the DT having the highest level of accuracy (83.72%). The results of this study have significant consequences for Bangladesh's microcredit programs and those in nations that are developing. Microcredit programs can focus their efforts on women who, based on their socioeconomic and demographic features, are most likely to benefit from the program by employing ML algorithms. This may result in more successful microcredit projects that support the empowerment of women and general socioeconomic growth.

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1. INTRODUCTION

Bangladesh is a South Asian developing country. It is the world's eighth-most congested country, with a population of approximately 164.69 million people and a working population accounting for 41% [1]. About 50.6% of the population is male, while 49.4% is female. With a yearly growth rate of 3.29%, nearly 38.2% of the population lives in a metropolitan area. Developing a country's gross domestic product (GDP) is critically important to its progress. Today's business venture plays an important role in the development of the economy. Business is perceived as the driving force of development in economies worldwide. Socio and monetary improvement rely upon numerous variables yet the main component is labor. It assumes a crucial part in the viewpoint of Bangladeshi monetary status. The populace is a significant resource for any country for the financial turn of events. Then again, a colossal populace isn't the lone factor that is liable for the improvement of the economy, it relies upon the business pace of the complete populace where guys and females are similarly answerable for this advancement of a country. Bangladesh has had financial development in the previous few years arriving at 8.153% GDP development in 2019 [2]. In developing and developed nations, the situation with men is as yet higher in different areas contrasted with women on the

planet. As Bangladesh is currently an agricultural nation yet the truth of the matter is the work support rate for women was just 36.3% in 2019 contrasted with 81.4% for men around the same time [3]. In the course of recent years, female-claimed organizations filled significantly in number, incomes, and work in a few nations. For instance, in Norway and Canada, almost 60-65% of the new organizations were begun by females [4]. However, the situation in Bangladesh isn't comparable. Being a piece of society, ladies' investment in dynamics and association in the economy is at a lower stage in Bangladesh.

Many women in Bangladesh are struggling with traditional jobs, limited opportunities for education and employment, and facing discrimination in the public eye. The lack of co-activity between men and women is hindering the nation's long-term sustainability [3], [5]. Men in Bangladesh play a significant role in women's financial advancement, yet they are often overlooked due to their societal position and lack of equal freedoms, often deterred from family and society. The United Nations put out 17 objectives that are an outline to accomplishing a superior and more manageable future for every one of us, the difficulties our reality and individuals in it face consistently. Supportable advancement objective number 05 of the 17 feasible improvement objectives set up by the assembled countries in 2015 is tied in with accomplishing sex uniformity and enabling all ladies and young ladies. Without satisfying sustainable development goal (SDG) objective number five ladies can't get their genuine status and pose before society, and a nation may not be ready to support its turn of events. Every nation faces explicit difficulties in carrying out the SDGs, and these needs will be a huge part of their prosperity [4]. Contrasted with different nations, for example, Sweden, Denmark, Norway, and Finland, Bangladesh is performing ineffectively.

Women's empowerment is the way toward enabling ladies to upgrade their status in society [1]. Microcredit, or microfinance, is a crucial tool for women's empowerment, providing small financial aid tailored to the less fortunate. It helps reduce poverty, increase food security, and boost women's economic growth, making it a risk-free venture [6], [7]. As Yunus [6] takes note, this happens "on the grounds that undeveloped or unskilled poor are not poor; they are poor since they can't hold the earnest returns of their work. The explanation is clear—the poor have no power over the capital that makes a judgment call, and poor country ladies work to help another person who controls the capital" [8]. This paper aims to identify financially independent women through microcredit and support, using machine learning (ML) algorithms to identify hard-working, dedicated, and willing workers, potentially boosting women's business vision and achievement rates.

Researchers in Bangladesh have studied women's empowerment, microcredit, business aspirations, and individual factors influencing women's entrepreneurial goals. Empowerment is crucial for national financial development and women's empowerment, as most women live in poverty. Microcredit programs have been shown to help alleviate poverty and attract women, particularly in some cases.

A few researchers saw that the microcredit program had gotten far-reaching acknowledgment as a feasible technique for empowering women, for example, more noteworthy abilities, decisions, and opportunities in dynamic. The examination is dependent on an example of 600 helpless ladies in eight locales of Rajshahi division, Bangladesh, and utilized relapse investigation for the exhibition assessment [9]. Another investigation uncovers that a miniature credit program is an extraordinary method to give little to the oppressed lady for independent work exercises. It additionally permits superior personal satisfaction and supports a lady to take part in the practical choices. The study was directed at 134 subjects. Information was gathered through interviews and the enlightening measurement was utilized to assess the women empowerment and job of microfinance behind this strengthening and the outcome shows a positive connection between miniature credit and lady strengthening [10]. A study has been done to identify a connection between women's empowerment and microcredit [11]. Studies were finished with 220 subjects of Aadhar Association Parishad under Shaltha Upazila in the Faridpur area, Bangladesh where 100 subjects were engaged in microcredit plots, and the rest were observed without providing any credit.

The empowerment of women likewise identified with interior elements. Family and society play a significant part in any woman in our general public. Albeit the Constitution of the Individuals' Republic of Bangladesh has given equivalent rights to the two women and men, the fact of the matter is outlandish. A few overviews have been done to identify that an obstacle from a family is the significant reason for a lady to turn out to be monetarily autonomous. In certain parts of Bangladesh, it is accepted that a man is the provider and considered top of a group of the family, and only a man can give monetary security to a family while a lady is dismissed leaving them in homegrown tasks. Md. Al Mamun, Md. Abdul Jabbar and Rebeka Sultana referenced in their paper that his investigations were led during the examination time frame. The complete number of tests was (60) sixty which 15 were from each Upazila (sub-area). Tests were taken from 04 Upazilas of 04 locales, specifically Bogura, Sirajgong, Ghaibandha, and Rangpur. A bunch of polls was set up to lead the field overview. The poll consisted of both shut and open-finished inquiries [4]. A few examinations have shown that men are multiple times more likely than ladies to stand firm on authority footings or arrive at high-level exploration positions [12].

Social and religious factors are likewise answerable for women's monetary development. This is an experimental exploration where a subjective relative contextual analysis is applied. Prodip [4] has done an exploration paper that shows social difficulties looked at by a woman to develop autonomously where a subjective similar contextual analysis is applied to 74 ladies. Information was gathered through a meeting in the neighborhood language and afterward converted into English. Information investigation was performed through discussion examination [13].

However, male-controlled society forces lawful and primary hindrances that forestall ladies back profiting by force, openings, and assets in schooling, preparing, experience, social and business organizations, and property rights expressed by liberal women's activist scholars. "Moderate reasoning made sexual orientation divisions that limited ladies' chances for the financial turn of events" [12], [14]. A few examinations show impediments of the capital give fewer freedoms contrasted with men. Then again, male business people share big networks with all the more high-status experts than do women. This is the significant reason that a lady experience building up her organization's introductory under-capitalization, which prompts underperformance [13]. A full article usually follows a standard structure: i) introduction, ii) method, iii) results and discussion, and iv) conclusion.

2.   METHOD

In this part, we have shown the proposed design of the framework. We have gathered information without anyone else reporting overviews after the factual investigation of the information obtained was performed. However, ML systems analyze the features and provide results. Furthermore, we have proposed four steps for this research namely collection of data, statistical analysis, examination of features, and finally the application of ML (supervised) algorithms. Figure 1 demonstrates the overall workflow that is followed during the experiment. All the stages are presented in the Figure 1.

Figure 1. Working procedure of the study

2.1. Data collection

Information is gathered using self-review in a nearby language and afterward deciphered in English. Data has been collected from three villages in three districts of Bangladesh namely, Narayanganj, Kishoreganj, and Jessore. We have provided BDT 4000 ($46.51) in 2020 to 43 subjects after verifying their condition directly. The fund was raised by crowdfunding and crowdsourcing and the rest of the respondents remained in the non-micro credit zone and collected data. Crowdfunding is the process of sourcing funds from a group of people and crowdsourcing is the process of sourcing skills or ends products from a group of people. We have done crowdfunding and crowdsourcing in Dhaka. After getting funds, ladies started their own poultry farms and looked after them. We collected data when they started their journey. After observing for almost 8 months again we received some data from the subjects for the final performance evaluation.

Self-report surveys could be utilized to identify successful women who accept microcredit. The overview comprised 21 demographical and categorical inquiries. We have flowed the overview among the ladies of Kishoreganj, Narayanganj, and Jessore. The study has been accepted utilizing online and offline as well. The factual estimations of the gathered information are referenced. The study was done by subjects who were 18-50 age limits and underprivileged. A similar number of qualities are taken care of in the ML models. Table 1 shows the statistical analysis of the study.

Table 1. Statistical analysis

Properties	Values
Age groups	18-50 years
Total collected attribute	21
Number of subjects (Narayanganj, Kishoreganj, and Jessore)	43 Person

2.2. Data pre-processing

In the information pre-preparing step, two types of work are executed. Firstly, redundant and inadequate overviews are fixed as we have collected data via interviews. Secondly, the dataset is prepared for further execution. After data preprocessing dataset is ready for the next step.

2.3. Examination of features

Feature analysis is the most significant and vital task. Features are characterized into vector conditions (1). Where f_i signifies the various features or attributes and n means the complete number of features. However, feature analysis was performed on categorical data in our research.

$$F = <f1, f2 \dots .fn>$$ (1)

2.4. Use of machine learning algorithms

We collected raw data sets by surveys from the respondent, and after pre-processing. ML is a type of data analysis that automates the creation of analytical models. It's a field of artificial intelligence based on the premise that computers can learn from data, recognize patterns, and make judgments with little or no human input [15]. To build the annotated dataset, we examined the features to be used in this phase. We analyzed by choosing 21 features and one class name. The annotated dataset was used to teach the systems in the context of supervised learning. In this study, conventional supervised ML algorithms were used. In this article, the training dataset is used 80% and the test dataset is used 20%. The algorithms are from four different types of classification algorithms. Naive Bayes (NB), sequential minimal optimization (SMO), k-nearest neighbor (k-NN), decision tree (DT), and random forest (RF) are examples of Bayesian, function-based, instance-based, and tree-based classifiers. For the performance measurement, we have followed the equations:

$$TPR = TP/(TP + FN); \; FPR = FP/(FP + TN); \; PR = TP/(TP + FP); \; RE = TP/(TP + FN);$$
$$F1 \; score = 2 * PR * RE/(PR + RE)$$

Here, true positive (TP), true negative (TN), false positive (FP), and false negative (FN). In Table 2 the performance is presented after calculations. One of the most highly used Bayesian classifiers is the NB [16]. It is used to solve a two-class problem that uses a probabilistic approach k-NN [17] is a non-parametric approach that can be used to solve classification and regression problems. The easiest and simplest way to handle classification and regression type of project and give acceptable results after performance evaluation is to use k-NN. It finds the nearest points from the cluster centers in each replication. A DT [18] is appropriate for multistage decision-making. It breaks up complex decisions into simple solutions. RF [19] generates trees to provide classification, feature selection, and proximity metrics. SMO is the name of a new SVM learning algorithm [20]–[22]. SMO uses an analytic quadratic programming (QP) step instead of the numerical QP step used in previous SVM learning algorithms.

Table 2. Performance metrics

Classifier	TPR	FPR	PR	RE	F1
NB	0.791	0.268	0.812	0.791	0.778
SMO	0.767	0.205	0.768	0.767	0.767
RF	0.767	0.279	0.782	0.767	0.754
k-NN	0.674	0.312	0.673	0.674	0.672
DT	0.837	0.145	0.845	0.837	0.831

3. RESULTS AND DISCUSSION

3.1. Result

In this paper, we have conducted our experiment using Python programming. We have used an online platform Kaggle. Kaggle is one of the most popular online platforms where programs can run their program. The traditional metrics such as true positive rate (TPR), false positive rate (FPR), precision (PR), recall (RE), f-measure (f1), Matthews correlation coefficient (MCC), receiver operating characteristic (ROC) curve, and accuracy (ACC) is used compared with other classifiers. The measurements are shown in Table 2 for each of the classifiers. Equations are presented:

$$ACC = (TP + TN)/(TP + TN + FP + FN)$$

$$MCC = (TP * TN - FP * FN)/\sqrt{(TP + FP)(TP + FN)(TN + FP)(TN + FN)}$$

In Table 3, the calculated data of the study are presented and compared whereas the DT shows a higher accuracy rate. Bar chart in Figure 2 demonstrates the comparison of the accuracy of algorithms which has been used for the experiment. From Tables 2 and 3, the DT is showing above 80% accuracy. Among all the classifiers DT algorithm offers the highest accuracy 83.72%. The f1-score of the classifiers is illustrated in the same fashion. The MCC and area under the curve (AUC)-ROC for classifiers, on the other hand, indicate different behavior.

Table 3. Values of ROC, accuracy, and MCC

Classifier	MCC	ROC	ACC (%)
NB	0.600	0.774	79.07
SMO	0.566	0.810	76.744
RF	0.555	0.856	76.74
k-NN	0.376	0.717	67.44
DT	0.723	0.836	**83.72**
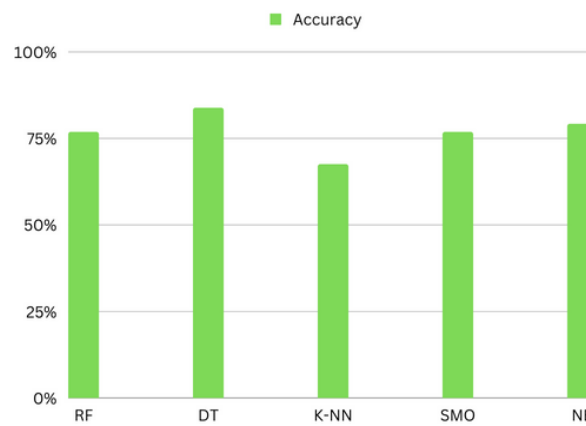
Figure 2. The classifier's accuracy is represented by a bar chart

The precision-recall curve is generated by calculating and graphing the precision vs recall for a single classifier at various thresholds. In Figure 3 we show all precision-recall curves for each classifier. The precision-recall curve values for each of the classifiers used in this paper are shown in Figure 3. Except for the NB, the curves are slightly overlapping. There is a minor difference between the recall and precision values for NB.
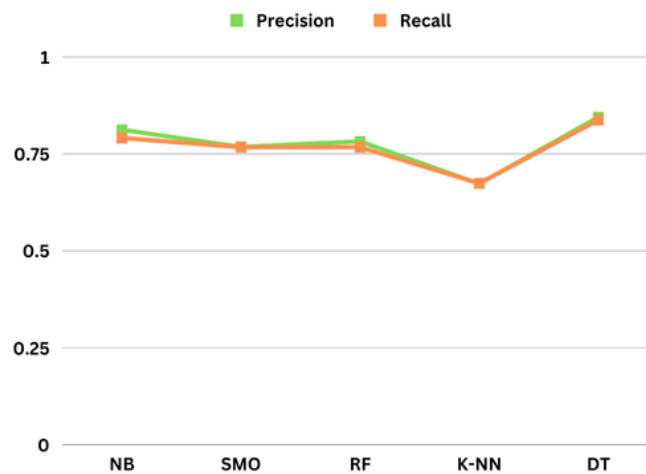
Figure 3. Each classifier's precision-recall curve

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The survey takes almost 8 months to execute properly. Table 4 shows the past and present status of women. A woman's life is completely changed after becoming a financially independent woman.

Table 4. Survey table

Facts	Before	After
Contribution to family and society	No	Yes
Decision-making right	No	Yes
Social status	No	Yes
Economic status	No	Yes
Financial security	No	Yes
Dignity and rights	No	Yes

3.2. Discussion

In this section, we'll discuss what we observed from this research. We have used five types of ML algorithms and observed some behavior. Tree-based classifiers have shown diverse results. NB shows good performance results in two-class problems and in this context, it shows the second-highest accuracy. On the other hand, k-NN represents the lowest performance. DTs have the highest accuracy among all the classifiers. Previous research has found a link between women's empowerment and microcredit. Microcredit is a one-of-a-kind innovation that elevates women's status and allows them to participate in socio-economic development, decision-making, and dignity [23]–[25]. The current study also shows that microcredit promotes women's empowerment. Mrs. Jamila Khatun (age 43) was one of the subjects of the recent study who was overlooked in family decision-making or other areas. But the reality is that the situation has completely changed. When a woman achieves financial independence, she is given full authority to participate in decision-making. She was unable to contribute to the well-being of her family in her past existence. However, she can now make a financial contribution to her family. It raises her ability to stand in the family and society. When a woman achieves financial stability, she is treated in society on an equal footing with men. Financial security improves, and a positive impact on society is created. Financial independence also contributes to women's empowerment. Mrs. Jamila Khatun (age 43) represents all other research participants who changed their lives after being financially independent women.

4. CONCLUSION

The current study was an attempt to learn how the use of microcredit and support can lead to women's empowerment in society and financial independence. By giving small financial assistance to female entrepreneurs, microcredit programs enable them to start or grow enterprises, break the cycle of poverty, and address gender inequity. Promoting financial knowledge, self-assurance, and skill development, empowers women and raises living standards, lowers gender gaps, and creates a more inclusive society. By using the unrealized potential of half the population, microcredit also improves whole communities. It improves socioeconomic empowerment, self-esteem, business skills, decision-making power, and confidence level. It also raises a man's status in society and ensures that he has equal rights and dignity. Despite the difficulties and inequality that still exist in many areas of the world, society is coming to understand the significance of empowering women and giving them access to equal rights and opportunities. It is critical to question and dispel misconceptions and preconceptions that hold women to be confined or limited in any way. In contrast, encouraging diversity, gender parity, and respect for women's autonomy and choices helps create a more just and equitable society for all. This study innovatively employs ML algorithms to predict women's empowerment based on microcredit. This research could add new dimensions to this field of research. It paves the way for future research in this area as well as interesting applications.

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