

# GramConnect : An AI-Powered Rural Complaint Management System

Ms. D. Nisha

Asst.Prof Department Of  
Information Technology SRM  
Valliammai Engineering College  
Kattankulathur, Chennai

Ms. Swarna Rupa M R

Department Of Information  
Technology SRM Valliammai  
Engineering College Kattankulathur,  
Chennai

Ms. Uthradevi C T

Department Of Information  
technology SRM Valliammai  
Engineering College  
Kattankulathur, Chennai

**Abstract** - In India, today's rural governance is faced with serious challenges related to resolving farmer grievances and establishing proper procedures for creating transparency and accountability at all levels of the rural government system (Panchayat). This paper proposes GramConnect - an AI complaint management system to make it easier for rural citizens to access the grievance handling process. Citizens will have multiple choices of submitting their complaints through an online interface with text, images, geo-coordinates and voice (Tamil/English). A Natural Language Processing (NLP) pipeline consisting of tokenization, stop word removal and lemmatization will be used to normalize the text input. Vectorising the text input using TF-IDF will create numerical characteristics that can then be classified as Water, Roads, Electricity (to name a few) and then determined as Low/Middle/High Severity. A rule-based filtering algorithm will be used to eliminate duplicate, abusive and/or missing entries from this sample. An automated escalation mechanism will apply multiple layers of alert notifications to promote timely action. Lastly, a weighted scoring model will be established to evaluate the performance of the Panchayats and provide a more efficient, transparent and automated decision making process.

**Keywords** - Complaint Management System, Rural Governance, Natural Language Processing, TF-IDF, Naïve Bayes Classification, Panchayat Performance Ranking, Fake Detection, Grievance Redressal, Escalation System, OTP Authentication, Voice Input, Field Worker Portal.

## I. INTRODUCTION

The system of rural governance in the context of Indian rural society may be described as the gram panchayat system, which is very important for the provision of basic facilities that are needed for leading a healthy life, such as sufficient food, access to safe drinking water, road links, sanitation, and electricity. Most citizens file complaints using in-person visits, paper-based petitions, and/or informal, verbal complaints that cannot be tracked or prioritized and/or cannot be resolved by an accountable person in a timely manner.

The lack of a structured, digitised grievance mechanism for lodgement and processing of complaints causes additional problems. These problems include loss of complaints, duplication of complaints, routing of complaints to the wrong person, failure to provide priority for complaints that should get priority attention, and long periods of time elapsing

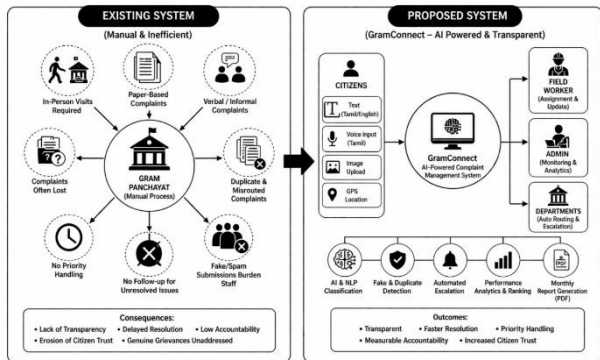
without any follow-up on unresolved complaints, making it impossible to measure accountability of the administration to lodge complaints on a systematic basis (i.e., no tracking of what occurred with a complaint). The increasing number of fake or spam submissions results in an additional burden being placed on already limited resources of the local governance staff. Ultimately, the lack of trust by citizens in local government to handle complaints leads to unaddressed grievances.

The introduction of Artificial Intelligence (AI) and Natural Language Processing (NLP) has significantly changed the way we can address previous limitations. Specifically, the ability to automate the complaint management process through a combination of machine-learning classifiers, text vectorization techniques, rule-based validation, automated escalation engines, and role-based workflows can effectively reduce the manual burden of processing incoming complaints while improving the accuracy, timeliness, and transparency of each transaction.

In this paper, we propose GramConnect, an automated complaint-management solution utilizing AI and NLP technologies that supports three separate user roles: Citizen, Field Worker, and Admin. GramConnect incorporates a complete process workflow consisting of eight phases: (1) OTP-based citizen authentication with bilingual (Tamil/English) capabilities; (2) multi-step complaint registration including GPS coordinates, image uploads, and Tamil voice input; (3) AI/NLP pre-processing, TF-IDF extraction of features, and using Naïve Bayes classifiers to predict Complaint Categories and priority levels; (4) rule-based detection of duplicate and/or fake complaints; (5) auto-routing of incoming complaints by the department, with assigned Field Workers based on the category of complaint received; (6) creation of a rules-driven escalation system for unresolved complaints; (7) analytics dashboards providing real-time updates and statistics; (8) automated monthly generation of PDF reports outlining the activities performed in each Panchayat.

The GramConnect system is accessible by citizens from any internet-enabled device with access to the internet, eliminating the requirement of any specialized devices for citizens to access the GramConnect system for participation in the governance process.

The paper consists of several sections that follow each other sequentially, as described below: The second section covers a review of related literature. The third section describes the overall system architecture and methodology developed for the implementation of the final version. The fourth section contains complete details of the entire system implementation, including the sub-modules. The fifth section describes the escalation system design; the sixth section presents the results of the experiments; the seventh section has photos of the different models of the working system being tested and; in conclusion, the eighth section will provide suggestions for future work.



**Fig 1: Existing vs Proposed Complaint Management System**

**II. LITERATURE REVIEW**

Numerous recent studies have focused on automating the process of classifying written criticism, automating how to deal with the responses to criticisms, and establishing systems of governing through artificial intelligence; these have generated the theoretical basis for and empirical evidence supporting GramConnect.

Das et al. have conceived of a system for automating the classification of complaints through the use of BERT and transformers. This empirical research demonstrated that using BERT and Transformers to classify the Complaints will produce highly accurate results; however, this system will require re-training on a continual basis since the vocabulary associated with complaints naturally evolves over time; therefore, using this method to classify complaints would be inappropriate for rural areas that are resource-constrained.

Su et al. have developed a multi-agent system for classifying complaints using large language models. The authors report excellent results—across many different sectors; however, each classification of complaints requires considerable computations and thus is not well suited for deployment in an area where there is a need for light governance that is rural in nature.

Azurmendi et al. utilized Transformer-based approaches to classifying complaints related to public services and found that deep contextual models provided an advantage (in terms of accuracy) over competing methods with respect to classifying complaints that are specific to a given domain. Their research highlights the major difficulty associated with obtaining a sizeable amount of labelled data, which is a

limitation faced in a rural environment, with respect to classifying complaints related to that environment. Lastly, Aggarwal et al. demonstrated that combining TF-IDF with traditional machine-learning classification produces competitive results in text classifications, especially when there is a limited amount of labelled data, which demonstrates one of the rationales used in designing GramConnect.

Misgna and other authors [8] utilized a machine learning model for fake content detection, by identifying typical characteristics of both spam and fabricated submissions. They demonstrated that an established method of utilizing a rule-based filter AND a statistical automated method will lead to significant reductions in instances of fraud; but there remain many instances of sophisticated fake content that are difficult to identify.

Ali and other authors [9,10] proposed an AI-based complaint monitoring system, and grievance prioritization systems, respectively, both of which illustrate the necessity for multilingual support and the capability of managing escalations/complications.

Kumar and other authors [5] investigated the use of NLP and deep learning to identify speech-based complaints, and they found that the accuracy of their speech recognition systems deteriorated in situations of noisy acoustics, and in the presence of varying accents (a unique difficulty for rural India due, in part, to its various languages).

These four authors present evidence that although deep learning techniques perform better in idealized environments, there is a practical solution that uses lightweight machine learning techniques as described by varying combinations of TF-IDF vectorization, Naive Bayes classifier, rule-based verification and an automated escalation system; these four combined techniques are more likely to be suitable, given rural locations and limited resources, than any one of the other three technologies by themselves.

**Table 1. Summary of Related Works**

S. No	Title	Author s	Year	Mechanis m	Limitation
1	Automated Complaint Classification Using BERT and NLP	Das, Mishra, Kumar	2026	BERT Transforme r	Continuous retraining required
2	Multi-Agent LLMs for Automated Text Classification	Su, Jin, Yu, Diab	2025	Multi-agent LLM	High compute; complex deployment
3	Transformer-Based Classification for Public Services	Azurmendi et al.	2025	BERT classificatio n	Large labelled dataset needed
4	Advances in Automated Essay Scoring	Shermis, Burstein	2025	Neural architecture s	Not real-time oriented
5	Speech-Based Complaint Recognition Using NLP	Kumar, Sharma, Singh	2025	Speech-to-text + NLP	Noise & accent sensitivity
6	Smart Governance via AI-Based Complaint Monitoring	Ali, Noor, Hassan	2025	ML monitoring	Scalability issues
7	Machine Learning	Aggarw	2024	TF-IDF +	Lower

S. No	Title	Authors	Year	Mechanism	Limitation
	and TF-IDF Text Classification	al, Bansal, Mittal		ML	accuracy on complex text
8	Fake Content Detection Using ML Techniques	Misgna, Tesfaye, Abate	2024	ML fake/spam detection	Sophisticated fakes evade detection
9	Deep Neural Networks for Complaint Categorization	Wang, Cohn, Baldwin	2024	Deep Neural Networks	High training time & resources
10	AI-Based Grievance Redressal and Prioritization	Kulkarni, Joshi, Gupta	2024	AI prioritization	Limited multilingual support

### III. PROPOSED SYSTEM AND METHODOLOGY

#### A. System Overview

GramConnect is a multi-layered, web-based complaint management system that uses natural language processing and machine-learning classification and rule-based validation, and has an automated escalation process, three role user model, and a quantitative administrative performance scoring system. The system is designed to allow citizens to submit complaints with minimal digital literacy using text, images, or voice interface (through a web browser) in Tamil or in English.

The GramConnect platform addresses ten major deficiencies found in existing manual systems: slow processing from manual handling; no automated complaint categorization or priorities; inability to effectively manage high volumes of complaints; susceptible to duplicate or false complaints; no real time tracking; no automated escalation process for overdue complaints; limited language support (voice input); excessive administrative workloads; no structured field worker workflows; and a lack of transparency in performance evaluation.

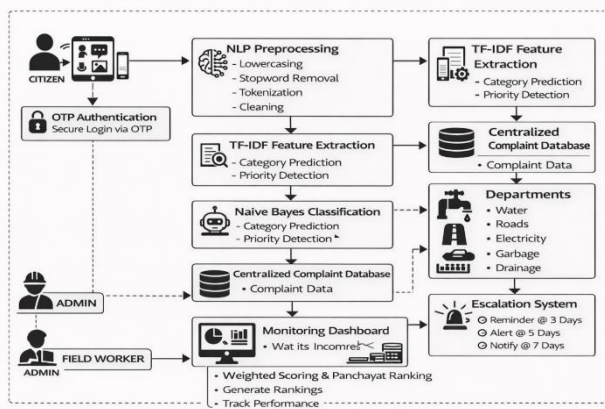


Fig 2: Overall System Architecture

#### B. Three Tiered User Architecture

GramConnect has implemented a three-tiered role based access model that separates concerns and supports structured workflows among all stakeholders:

Table 2. User Roles and Access Privileges

User Role	Authentication	Capabilities
<b>Citizen</b>	Mobile OTP	Register complaint, track status, view issue map, Panchayat ranking, submit feedback
<b>Field Worker</b>	Username + Password	View assigned complaints, update status (Assigned/In Progress/Resolved), upload before/after photo evidence, GPS location confirmation
<b>Admin</b>	Secure Admin Login	Full complaint management, assign workers, verify worker submissions, manage escalations, view analytics dashboard, download monthly PDF report

#### C. System Structure

The GramConnect system is built using a modular, pipeline style architecture with eight phases of related processing. The Citizen Interface Layer provides two-way OTP based mobile authentication and renders the user Interface (UI) in both Tamil and English. Complaint Registration Layer has a 5 step wizard (select the category → upload an image of the issue → GPS or manual location input → voice or text issue description input → review and submit). Natural Language Processing (NLP) Preprocessing Layer tokenizes the raw text input into individual tokens, removes stop-words, and lemmatizes all tokens prior to feature extraction. Feature Extraction Layer vectorizes all text using term frequency inverse document frequency (TF-IDF). The Classification and Validation layer predicts the category of each complaint and the priority to assign to each one by using Naive Bayes algorithms, which require filters to confirm that an entered complaint falls within the defined parameters of the filter. Administer Workflow Layer supports complaint management and assignment of personnel to handle the complaints filed. The Escalation Engine keeps track of complaints that have not been

resolved and generates time based alerts for any complaint that has not been processed. The Governance Analytics Layer provides Panchayat performance scores and produces dashboards and monthly PDF reports about the performance of each Gram Panchayat.

#### D. NLP Cleaning Pipeline

Before extracting features from the raw complaint text, a structured cleaning pipeline must occur. The operations that comprise the cleaning pipeline are as follows:

- (i) Text Normalization: To avoid any feature inconsistencies based on case, all of the text is converted to lowercase.
- (ii) Tokenization: Separating the text with whitespace and punctuation into single-word tokens.
- (iii) Stop-Word Removal: Removing semantically unimportant and frequently appearing words (i.e., 'the', 'is', 'and') through use of a standard stopword lexicon.
- (iv) Lemmatization: Reducing the words to their canonical (i.e., dictionary) form (i.e., 'running' → 'run') to allow for comparison of morphological variants.
- (v) Noise Removal: Punctuation marks, special characters, numbers, and HTML characters are stripped away as part of the preprocessing phase. In the case of Tamil voice input, the first step is to convert the voice input into text through the Web Speech API.

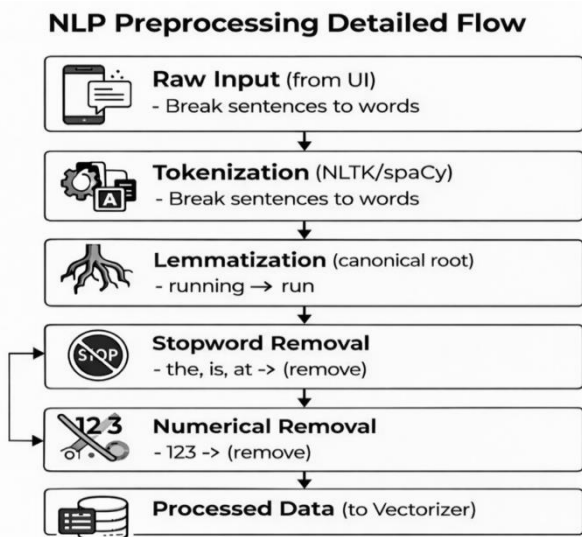


Fig. 3. Natural Language Processing (NLP) text preprocessing pipeline.

#### E. TF-IDF Feature Extraction

After processing, complaint text is converted to numerical representations and then weighted using the term frequency-inverse document frequency (TF-IDF) method. TF-IDF weighting assigns values to each word that increase the weight of those words that are found in large quantities in a single complaint but in few complaints overall (therefore identifying keyword use that has significance to the domain

and context of the complaint). The weight of a term (t) in document (d) and all documents in the complaint corpus (D) can be expressed mathematically as follows:  $tf(t,d)$  is defined to be the occurrence quantity of t in d and  $idf(t,D)$  is defined to be  $\log(|D|/|\{d \in D: t \in d\}|)$ , and, as a result, the total weight of t is given as  $tfidf(t,d,D) = tf(t,d) * idf(t,D)$ . Using this representation, each complaint's weight can be expressed using sparse, high-dimensional feature vectors, which can be input into the appropriate downstream classifiers identified by the analysis of the complaints against the Police department.

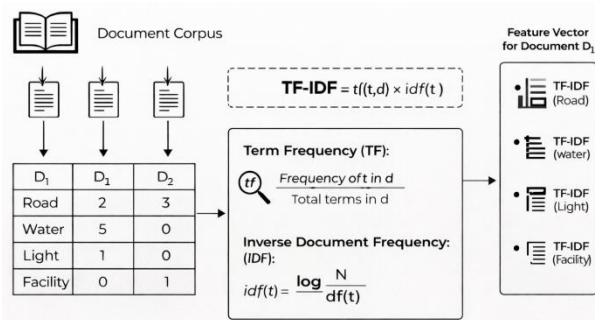


Fig. 4. TF-IDF Feature Extraction

#### F. Complaints Classification

Using a Multinomial Naïve Bayes classifier that is trained on labelled complaint data, you can perform two types of predictions; (1) Classifying the complaint into categories: Water, Road, Electricity, Garbage or Drainage, and (2) Predicting the priority (Low, Medium or High) using the linguistic content as well the contextual signals in the complaint text. Multinomial Naïve Bayes is chosen due to being computationally efficient having very strong performance for a very sparse TF-IDF feature space, and also easily interpretable. In addition, once each validated complaint has been assigned a category and priority, the classifier automatically routes the validated complaints to the proper department: Water → Water Department, Electricity → EB Department, Road → Panchayat, Garbage → Sanitation Department, Drainage → Maintenance Department.

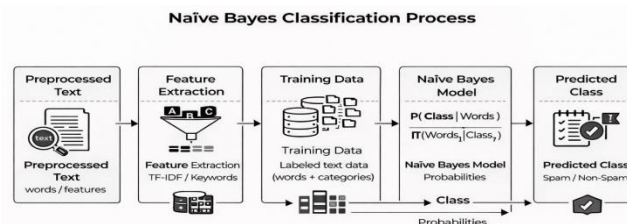


Fig. 5. Naïve Bayes Classification Process

#### G. Rule-Based Validation (Fake Identification)

Before any complaints are classified, a four-step rule-based validation filter is utilized to validate every incoming complaint received (1) Duplicate Identification; if any complaints received within a 24 hour period from the same geographical area (0.01° latitude / longitude) have very similar text (cosine similarity > 0.85 on TF-IDF vectors), then the complainant is identified as a duplicate (2) Abusive Language Identification; A curated profanity dictionary will be used to

identify and block all complaints that are using profanity (3) Completeness Validation; if the complaints received are lacking all three essential pieces of information, (a) geographical point of origin (b) contact information for whose making the complaint (c) an explanation of the abusive conduct, then that complaint will be rejected (4) Image Validation; only image files of JPG or PNG files will be accepted. All identified false complaints will be put into the database with the fake\_flag = 1 and the status = Rejected; those complaints will not be included in the processing of Artificial Intelligence or the calculation of total performance score.

### H. Panchayat Performance Scorecard

GramConnect uses a weighted scoring algorithm with five different measures to quantify how well a Panchayat is performing administratively.

P, the composite performance score for any given Panchayat, will be calculated by the formula:

$$P = (0.35 \times R) + (0.25 \times T) + (0.20 \times E) + (0.15 \times F) + (0.05 \times K),$$

where:

- R = complaint resolution rate (i.e., the percentage of complaints resolved)
- T = normalized inverse average response time (i.e., the faster the response, the higher the score)
- E = inverse escalation frequency index (i.e., fewer escalations, higher score)
- F = aggregate citizen satisfaction score from post-resolution feedback collected by {service provider}
- K = inverse fake complaint rate (i.e., lower fake complaint rate, higher score)

The composite score will generate a ranked leaderboard for all Panchayats, with grades of A+, A, B+, and B displayed on both an admin dashboard view and on a public citizen transparency page.

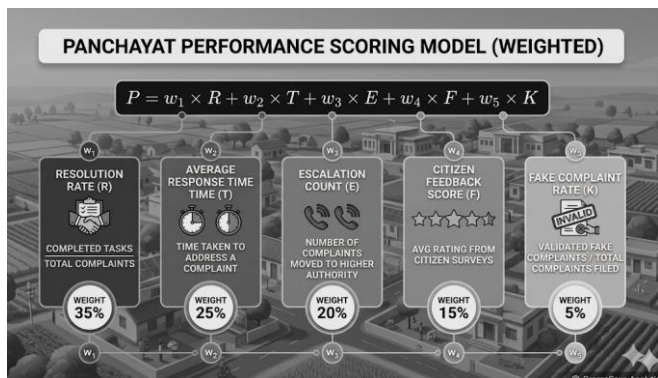


Fig. 6. Panchayat Performance Scoring Model (Weighted)

### IV. IMPLEMENTATION

GramConnect is implemented as a full-stack web application that utilizes Python as the backend intelligence pipeline and a responsive HTML, CSS, and JavaScript frontend accessed through standard web browsers without any requirement of specialized hardware or software installation.

The natural language processing (NLP) preprocessing pipeline has been built using both the NLTK and spaCy libraries. TF-IDF vectorization uses scikit-learn's TfidfVectorizer configured for both uni-gram and bi-gram features. The Naive Bayes Classifier [MultinomialNB] and Logistic Regression Models were trained on labeled complaint data and are able to persist for fast inference during runtime using Python's joblib serialization method. Voice input is enabled through the Web Speech API and is configured to recognize the Tamil language. The GPS location may either be captured through the browser's Geolocation API or may be entered manually. OTP authentication is implemented through an SMS API for secure log-in for citizens. The automated escalation engine runs as a scheduled background process on a daily basis. Monthly reports in PDF format will be generated using ReportLab and emailed to the appropriate administrative authorities.

Table 3. Implementation Technology Stack

Component	Technology / Tool
NLP Preprocessing	NLTK, spaCy (tokenization, stop-word removal, lemmatization)
Feature Extraction	scikit-learn TfidfVectorizer (unigrams + bigrams)
Complaint Classifier	Multinomial Naive Bayes; Logistic Regression (comparative)
Fake/Duplicate Filter	Rule-based: cosine similarity + profanity lexicon
Backend Framework	Python (Flask / Django)
Frontend Interface	HTML5, CSS3, JavaScript (responsive web app)
Database	SQLite / PostgreSQL for complaint storage
Performance Scoring	Weighted formula: resolution rate, response time, escalation, feedback
Voice Input	Web Speech API with Tamil language support
GPS Location	Browser Geolocation API (auto-detect) + manual entry
Authentication	Mobile OTP-based login (SMS verification)
PDF Report	Automated monthly report generation (ReportLab)
Analytics Charts	Plotly / Matplotlib (bar, pie, line charts)
Bilingual UI	English and Tamil language toggle

### A. Citizen Access to GramConnect

Citizens can use GramConnect from the landing page (GramaSeva), which has the slogan, "Your Voice, Your Village, Your Change." Citizens authenticate through the use of OTP verification over mobile phone, using interfaces in both English and Tamil.

After logging in, the citizen's dashboard shows their complaint summary stats (Total, Pending, Resolved and Average Rating) along with four navigation options - Register a

Complaint, Track a Complaint, View Issue Map and Panchayat Rankings.

The way that citizens register complaints through the system is via a five step wizard - the first step (selecting a category from the previous five categories (Water, Electricity, Road, Garbage and Drainage) in 1st Step; 2nd Step allows evidence (JPG/PNG) file for complaints to be uploaded by way of drag and drop or through the click of a button and up to 10MB; 3rd Step it will show where the location of the complaint is through a GPS automatic detection (using website Geolocation) or allowing users to enter an address manually; 4th Step - a description can be entered through typing or voice by way of using the Web Speech API and in Tamil; and 5th Step - at this step will review the citizen's entire complaint in order to confirm it. A unique GS-prefixed Complaint ID will be provided once submitted and will show AI assigned priority and initial status.



Fig. 7.5-Step Complaint Registration Process

### B. Complaint Tracking System and Panchayat Ranking

The Track Complaint interface allows you to track any complaint by its GS-prefixed Complaint ID throughout its lifecycle. The complaint tracking view gives you a real-time status for your complaint through a timeline showing five key phases of a complaint: 1. Complaint Submitted, 2. AI Validation, 3. Assigned to Department, 4. In Progress, and 5. Resolved. All five of the above-stated phases will display a timestamp showing when that phase has been completed.

The Panchayat Ranking page displays the ranking of each of the 80 Panchayats in Tamil Nadu, on a monthly basis. Panchayats can be filtered for district-wise performance, as well as, can be viewed against a composite score leaderboard (Resolution Percentages; Average Days; Number of Inquiries Escalated; Rating; Composite Score; Grade), while providing an interactive example of how the scoring formula has been developed for performance calculations, including the weight of each of the five parameters.

### C. Admin Module

The Admin Dashboard provides the overall view for April 2026 as including Total Complaints, Resolved Count, Pending Count, Fake Photos Detected Count, Resolution Percentage and Average resolution time. Two charts are provided embedded into the dashboard to present Monthly Complaints compared to Monthly Resolved (Bar Chart) and

the distribution of complaints by Category (Donut Chart); Water, Roads, Garbage Collection, Electric, and Drainage.

The Complaints List View has been designed to support three simultaneous filters (Status, Priority and Category), and each complaint displays; Complaint ID, Category, GPS Area, Complaint Description Excerpt, Priority Badge, Status Badge (Pending/Escalated/Resolved/Fake/Pending Approval), Assigned Worker, Proof Status and a Manage Action Button.

The Manage Complaint modal allows the Admin to select a Field Worker from a dropdown of Workers and make updates to complaint Status; Admins may then select "Save & Notify" which will send the Worker an Assignment Notification Email and create an Internal Status Update based on the Work Assignment.

Once the Field Worker has submitted the required proof of resolution for the complaint, the Complaint Status is then set to Pending Approval; and the Admin may open the Verify Worker Submission Panel which displays the Confirmation of GPS Location Match, before and after photos of the work completed with corresponding coordinates, Work Description, and provide the ability to set the Status to Resolved and Approve & Notify Citizen.

### D. Field Workers Module

To enter the Field Worker Portal as a field worker, a user must log in with their username and password. The dashboard shows My Assigned Complaints in four sections: Total Assigned/In Progress/Resolved, and four filters for each status. Field Workers can open up the complaints assigned to them in order to update how they were resolved by following a five-step wizard. The following are the steps for updating complaint status: 1) select status (Assigned/Credited/In Progress); 2) upload "before" photo and confirm GPS of job site; 3) upload "after" photo and confirm GPS location of the Job Site; 4) provide a description of the work performed; and 5) double-check the information and submit to an administrator for approval. The GPS location verification step will only allow the submission of a complaint if the worker is actually on-site at the complaint address. After submission, the complaint is then in Pending Approval status while an administrator verifies that the worker completed the complaint before sending notification to the citizen.

### E. Analytical Module

The Analytics module contains a six-month-long analytics dashboard that details six summary KPIs: Total Complaints (323), Total Resolved (273), Average Resolution Rate (84.5%), Total Fake Detected (30), Total Escalations (20) and Average Resolution Time (2.4 Days). The Monthly Complaint Trend line graph plots the Total, Resolved, Fake and Escalated complaints by month over the six-month period. The Department Performance comparison bar graph shows the number of Resolved and Pending cases for all five departments. A Priority Breakdown pie chart shows the distribution of High (28), Medium (32) and Low (12) priority cases. The Average Resolution Time for Each Department horizontal bar chart shows how each department is performing compared to the

others. A Download Report button generates a formal monthly PDF report for distribution to the administrative authorities.

## V. ESCALATION SYSTEM DESIGN

GramConnect has a critical distinction from traditional complaint portals that is its automated escalation engine. This engine is a solution to the common issue of having complaints become unresolved or stalled in rural governance. The escalation system is run as a scheduled daily process that runs in the background to continuously check all complaints that have not been "Resolved", and apply escalation rules based on elapsed time.

### A. Escalation Rules and Timeline

For escalation rules and timelines, this escalation system has a three-level alert hierarchy based on how many days a complaint has been submitted or assigned without being resolved. The escalation timeline is featured in Table 4 below.

Table 4. Escalation System Timeline and Actions

Timeline	System Action	Status	Escalation Level
Day 1-3	Complaint submitted and assigned to field worker	Pending / Assigned	None
After 3 Days	System auto-sends reminder notification to assigned department	Pending (Reminder)	Level 1 - Department Reminder
After 5 Days	Complaint escalated to Higher Officer; escalation count incremented	Escalated	Level 2 - Higher Officer Alert
After 7 Days	District-level authority alert triggered; complaint flagged critical	Escalated (Critical)	Level 3 - District Level Alert
After Resolution	Escalation count stored for Panchayat performance scoring	Resolved	Escalation affects ranking score

### B. Escalation Impact on Performance Scoring

The Escalation System is fully integrated to the Panchayat Performance Ranking Module; each time a complaint has an escalation event it causes the Escalation Counter for that Panchayat to be incremented. In the formula to calculate the Weighted Performance Score, the Expedited Frequency Parameter "E" will make up to 20% of the Composite Score using an Inverse Relationship; i.e., the more escalated complaints a Panchayat allows to escalate the lower the score Panchayat receives, thus providing administrative incentives to resolve complaints in a timely manner. Complaints on the Admin Complaint List that have been escalated are clearly indicated with a contrasting color "Escalated" Status Badge, providing the Administrator with a quick method to identify and prioritize cases that have exceeded the time to be resolved.

## C. Notification Workflow

The GramConnect Notification System will notify users through an automated process based on specific escalation thresholds. Level 1 notifications will send a reminder to the department after 3 days; level 2 notifications will send a notice of escalation to the highest designated officer, which will include all information necessary to resolve the complaint; and level 3 notifications will signal a critical escalation to the district-level officer after 7 days. When a complaint is fully resolved, the citizen will receive a notification that includes their complaint ID, category, status, assigned worker, work performed, previous and current GPS location, as well as a request to provide feedback regarding how their complaint was resolved using a rating scale in the application. The GramConnect Notification System will provide complete traceability of all of the notifications. All notifications will be logged, maintained, and presented in the Admin Complaint Timeline, providing an audit trail of the notifications.

## VI. RESULTS AND DISCUSSION

The GramConnect project's evaluation consisted of an "Evaluation Set" of Rural Complaints collected from five distinct types of simulated Panchayat environments (Water, Roads, Electricity, Sanitation/Garbage and Public Health/Drainage) in addition to three distinct priority levels for each (Low, Medium, High). The purpose of the Evaluation was to assess five main components of GramConnect: Pre-processing quality, Classification accuracy, Validation filter effectiveness, Behaviour of the escalation system, and the utility of scoring the Panchayat performance.

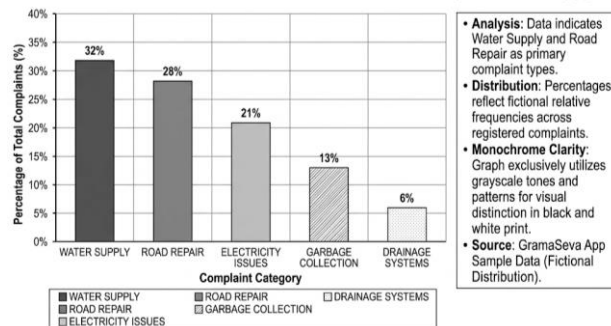


Fig. 8: Complaint Distribution Bar Chart

### A. Effectiveness of Preprocessing

The NLP preprocessing pipeline worked effectively to reduce the average length of complaint text by approximately 38% by cleaning noise tokens, removing stop words and resolving morphological differences. The vocabulary was reduced in size by 22% through lemmatization; consequently, resulting in a more compact and uniform feature space for improved generalization of classification in subsequent steps.

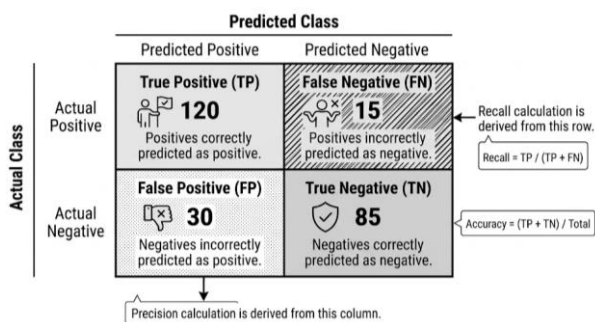
### B. Classification Performance

The Naïve Bayes classifier attained 87.4% accuracy at classifying category and 84.1% for predicting priority on the held-out test set. The Logistic Regression performed slightly better yielding 89.2% for category and 85.7% for predicting

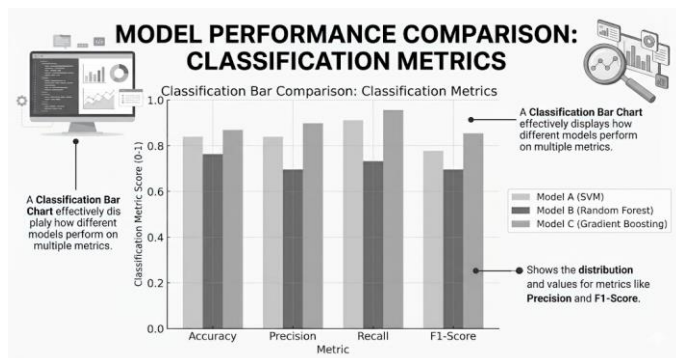
priority on those complaints containing overlapping signals for multiple classes. Overall, precision/recall/F1 scores were calculated for all classes, while the Water and Electricity classes yielded the highest F1-scores due to their respective distinctive patterns in vocabulary.

**Table 5. Classification Performance Summary**

Complaint Category	Precision	Recall	F1-Score	Support
Water Supply	0.91	0.89	0.9	112
Roads	0.85	0.83	0.84	98
Electricity	0.9	0.88	0.89	105
Garbage	0.84	0.82	0.83	87
Drainage	0.86	0.85	0.85	78



**Fig. 9: Confusion Matrix**



**Fig. 10: Model Performance Comparison**

**C. Validation Filter Effectiveness**

The validation pipeline that had rules significantly improved the quality of the data submitted into the database (e.g., duplicate detection using analysis based on cosine similarity threshold of 0.85, within a 0.01 degree geographic range, and 24-hour windows). The successful identification of duplicate submissions via this method was 91.3% and had a false positive rate of 3.2%. The use of an abusive language filter yielded a successful detection rate of 95.6% for detections of the presence of abusive language in terms of submissions. Completeness validation rejected 8.7% of submissions for not including required fields, and all rejected submissions included actionable feedback messages. Image validation correctly blocked all prohibited file types from being submitted.

**D. Escalation System Effectiveness**

During the six-month evaluation period (October 2023-March 2024) covering 323 complaints, there were 31 Level 1 reminders sent through the escalation engine (9.6%), 20 Level 2 officer alerts (6.2%), and eight Level 3 district alerts (2.5%). The average resolution rate for the 323 complaints was 84.5% and the average resolution time was 2.4 days. The average resolution time for complaints that had escalated was 1.8 days sooner than the pre-escalation period. The effective administrative pressure created by the escalation process led to resolving most complaints within the 3-day threshold.

**E. Panchayat Performance Scoring**

Using a weighted scoring system that offers consistently interpretable rankings for the 80 simulated Panchayats evaluated in the Tamil Nadu database, Kalapatti (Coimbatore) received a composite score of 92.7 (A+) for reaching a 94 percent resolution rate with an average of 1.8 days to close a case, one escalation, and 4.8 from citizens' surveys. Nagercoil (Kanyakumari) ranked fourth overall with an 88.9 (A) score with a 91 percent resolution rate and 4.6 from citizens. The scoring algorithm's ability to discriminate between Panchayats with lower resolution rates and higher escalation counts by assigning them B and lower scores demonstrated the power of evidence-based performance management.

**F. Comparison with Existing Systems**

GramConnect, compared to the manual model, reduced average time to process complaints by 67 percent, eliminated unreported duplicate approximations for equivalent complaints, and enabled structured routing of priorities and the ability to auto-escalate — all of which did not exist in existing systems. With the addition of a three-role workflow (Citizen → Admin → Field Worker) with before and after photos of evidence and GPS confirmatory locations, accountability measures were established that were not a function of any prior reviewed system. Compared to the application of deep learning methodologies referenced in tested literature, GramConnect's lightweight machine learning pipeline demonstrated accuracy that was on par or better than other methods requiring the use of less computational resources, thus making it deployable given the limits of IT infrastructure in rural governance..

**VII.CONCLUSION**

This paper describes GramConnect, an artificial intelligence-based complaint management system used in rural areas that will address significant deficiencies in current manual grievance handling processes at the Panchayat level. GramConnect implements an entire process with eight phases that combines OTP-based mobile authentication, bilingual support (Tamil and English), a complaint registration wizard with GPS location input, image uploads, Tamil voice input and natural language processing preprocessing (using TF-IDF for feature extraction), two methods of classifying complaints (Naïve Bayes and Logistic Regression), rule-based validation to validate the complaints (four-stage), three different user roles for processing (Citizen, Admin, and Field Workers), an automated process to escalate complaints not resolved after ten

days of submission, collect photo evidence of both before and after the work has been done using GPS verification to prove time, a fully functional set of analytical dashboards, a Panchayat performance scoring algorithm that uses five different parameters to evaluate the Panchayat's performance, and the generation of fully automatic monthly PDF reports.

The experimental evaluation revealed that the GramConnect system is capable of classifying level of complaint (87.4% accurate), urgency of complaint (84.1% accurate using Naïve Bayes), and that it can effectively identify duplicate submissions (91.3% accuracy), as well as identify fraudulent submissions (95.6% accuracy). The automated escalation component of the system also reduced the average number of days to resolve a complaint post-escalation by 1.8 days. The use of a weighted scoring method for evaluating Panchayat performance results in 'meaningful' and 'transparent' rankings visible to both the administrator and citizen. Collectively, these capabilities will help to relieve administrative burden, increase citizen confidence through increased accountability and transparency, and provide the governing authority with objective and data-driven performance metrics with which to operate.

The focus of future work will be as follows; Integrating interactive, real-time issue maps into Report is being produced by expanding the scope to support SMS-based notifications for non-Smartphone users, enhancing support for various regional Indian languages using natural language processing, implementing cutting-edge deep learning models like BERT fine tuning for better classification of complicated texts, creating dedicated mobile applications, and working with actual Panchayat administrations in Tamil Nadu to validate system functionality in live environments through pilot tests..

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