Improving the performance of Pakistan's judicial system and its ranking using data analytics

By

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Fall 2018-MSCS-276056

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A thesis submitted in partial fulfillment of the requirements for the degree of Masters of Science in Computer Science (MS CS)

In

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Islamabad, Pakistan.

(June 2022)

THESIS ACCEPTANCE CERTIFICATE

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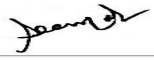
Signature: 

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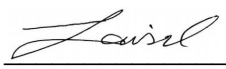
Signature: 

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Dedication

I dedicate this thesis to my beloved wife, parents, and teachers who encouraged me throughout my academic career.

Certificate of Originality

I hereby declare that this submission titled "Improving the performance of Pakistan's judicial system and it's ranking using data analytics" is my own work. To the best of my knowledge it contains no materials previously published or written by another person, nor material which to a substantial extent has been accepted for the award of any degree or diploma at NUST SEECS or at any other educational institute, except where due acknowledgement has been made in the thesis. Any contribution made to the research by others, with whom I have worked at NUST SEECS or elsewhere, is explicitly acknowledged in the thesis. I also declare that the intellectual content of this thesis is the product of my own work, except for the assistance from others in the project's design and conception or in style, presentation and linguistics, which has been acknowledged. I also verified the originality of contents through plagiarism software.

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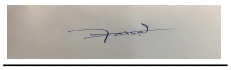
Student Signature: 

Acknowledgments

Glory be to Allah (S.W.A), the Creator, the Sustainer of the Universe. Who only has the power to honour whom He please, and to abase whom He please. Verily no one can do anything without His will. From the day, I came to NUST till the day of my departure, He was the only one Who blessed me and opened ways for me, and showed me the path of success. Their is nothing which can payback for His bounties throughout my research period to complete it successfully.

Faisal Mehmood

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Abstract

A large number of lawsuits are pending with various courts in Pakistan. This large number of pending lawsuits indicates the ineffectiveness of the justice system. An ineffective justice system contributes to decreasing the rank of the country in the World Justice Project (WJP), which is an international body, working for the advancement of the rule of law worldwide. Unfortunately, the rank of Pakistan in the WJP remained constantly low since Pakistan became a member of the WJP. This thesis aims to improve the effectiveness of the justice system in Pakistan using data analytics. The proposed solution contains two parts. The first part is a legal dashboard that provides insights into various lawsuits registered with the Supreme Court of Pakistan and its sub-courts. On the basis of these insights, higher management of the judiciary will be able to monitor their performance and devise strategies to improve weak areas, which can help improve the rank of Pakistan in the WJP. The subjective evaluation of the effectiveness of this part was done by legal practitioners and students of Islamabad-based renowned law schools. The majority of the evaluators were of the opinion that the proposed solution will be helpful in improving the effectiveness of the country's justice system. Past judgments act as a reference in the current court proceedings. That's why legal practitioners spend a significant amount of time reading past judgments. The majority of the time, after reading a judgment, it is found that the judgment did not contain the information of interest. This results in the wastage of time and effort. Topic modeling is an important technique for getting insight into textual documents. The second part of the solution is a topic modeling technique that will help legal practitioners find whether judgment(s) is of their interest or not. We implemented three topic modeling techniques i.e., LDA, LSA, and HDP on legal judgments. The performance of the topic modeling techniques was evaluated on the basis of the coherence CV score. The HDP model outperformed all other techniques for extracting topics from legal judgments.

Chapter 1

Introduction and Motivation

This section will introduce the World Justice Project (WJP), its different factors, and the rank of Pakistan in the WJP. Apart from that, this chapter will discuss the problem statement, research objectives, and key contributions of this study.

1.1 Introduction

An effective justice system is a fundamental component of developed countries. It safeguards human rights, resolves disputes in an efficient manner, and ensures the rule of law in the country. Studies indicate that the rule of law is highly correlated with high economic growth, a high level of education, a high level of peace, and low inequality [39]. But unfortunately, the justice system in Pakistan is ineffective. A large number of lawsuits are pending with various courts in the country. These pending lawsuits result in a lack of trust in the justice system of the country among the general public and eventually cause a low rank in the World Justice Project (WJP), which is an independent and multi-disciplinary organisation striving for advancement of rule of law worldwide [39]. Pakistan has been a member of the WJP since 2015. In the year 2015, 102 countries around the world were the members of the WJP, where Pakistan achieved 98th position. In the year 2016, 113 countries were the members of the WJP, where Pakistan secured 106th position. In the year 2017-18, 113 countries were the members of the WJP, where Pakistan secured 105th position. In the year 2019, 126 countries were the members of the WJP, where Pakistan secured 117th position. In the year 2020, 128 countries were the members of the WJP, where Pakistan secured 120th position, and in the year 2021,

139 countries were the members of the WJP, where Pakistan secured 130th position. It can be observed that the number of member countries increased with every passing year, which is evidence of the importance of WJP. Figure 1.1 shows the comparison of the score of Pakistan in the WJP for the past 7 years [37].

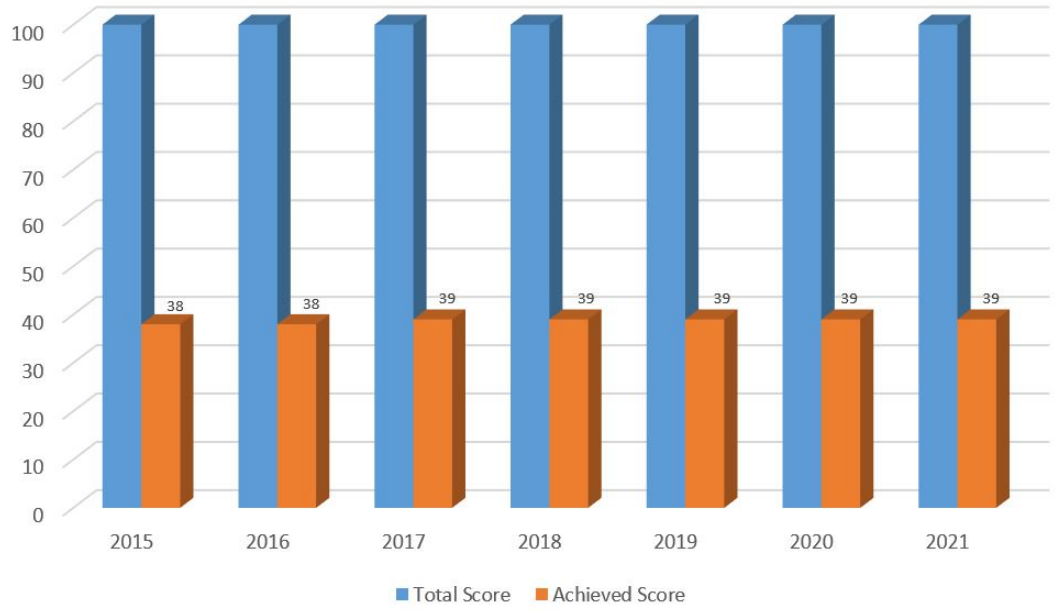

Figure 1.1: Pakistan's Overall Score in the WJP (2015-2021)

It can be seen that Pakistan's overall score in the WJP remained constantly poor during the past 7 years. The WJP score is calculated on the basis of nine factors, which have been assigned equal weightage. Since the scope of this study is limited to the judiciary of Pakistan so the study will be focusing on three factors of the WJP i.e., civil justice, criminal justice, and order & security in particular, and all other factors in general. Figure 1.2 shows the score of Pakistan for civil justice, criminal justice, and order & security for the past 7 years [37].

It can be seen that Pakistan's score in civil justice, criminal justice, and order & security remained constantly poor during the past 7 years, which indicates that the legal system of the country is ineffective and needs improvement. Since factors other than civil justice, criminal justice, and order & security are indirectly associated with the country's legal system and can be improved by making the legal system effective. We analysed an expert questionnaire related to the legal domain (used by the WJP) in consultation with a legal expert from the Supreme Court of Pakistan to understand the nature of the

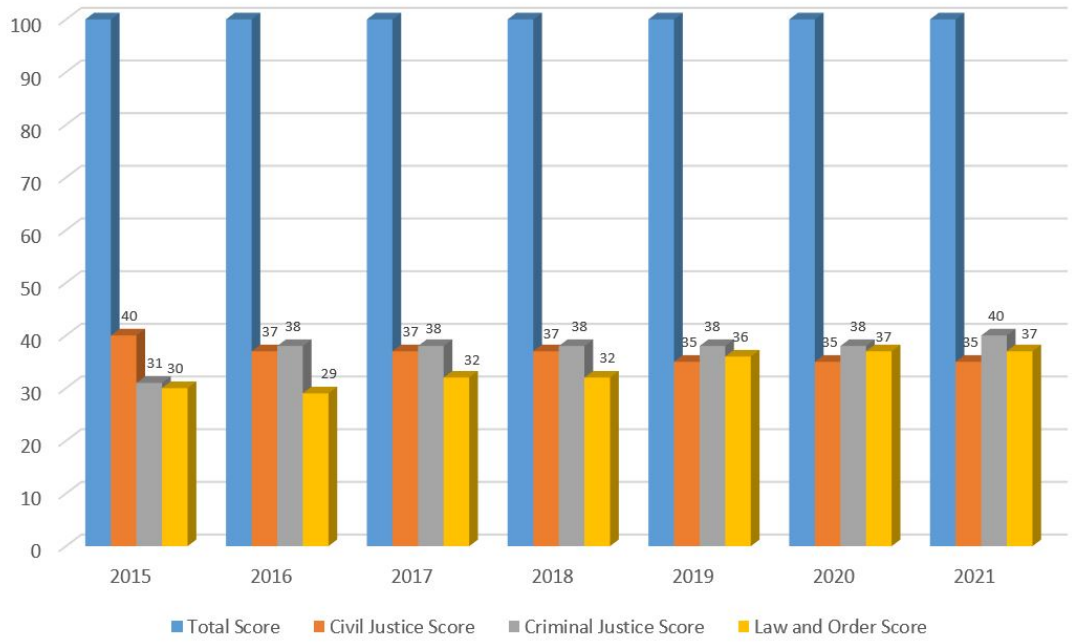

Figure 1.2: Pakistan's Score in Civil Justice, Criminal Justice, and Law and Order (2015-2021)

lawsuit data required for the creation of legal dashboard.

1.2 Background

The WJP covers 139 countries and jurisdictions. The rule of law involves the stability of law, institutions, norms, and commitments related to the community. The WJP states that the government, as well as the private entities of the country, are accountable under the law. According to the WJP, the law of the country must be clear, stable, accessible to the public, and must be enforced without any discrimination. The country should make sure that human rights and procedural rights are not being violated. The processes of the administration of law must be publicly available, fair, and efficient, and the provision of justice must take place in a timely manner.

The WJP involves more than 138,000 household surveys and 4,200 expert surveys [40], which act as a tool for measuring the rule of law in different member countries. Household questionnaires are filled out by the general public whereas the expert questionnaires are filled out by experts from the domain of law, academia, and public health. The respondents provide information on the basis of their experience and the everyday situation in the country. The WJP score is calculated on the basis of nine factors which

include civil justice, criminal justice, order & security, regulatory enforcement, absence of corruption, open government, constraints on government powers, fundamental rights, and Informal justice. These nine factors contain overall 47 indicators. The details of these nine factors and their indicators are mentioned below:

1.2.1 Civil Justice

1. Common people can afford and have access to civil justice
2. There is no discrimination in civil justice
3. Civil justice is corruption-free
4. Civil justice does not involve the improper influence of government
5. Civil justice does not involve unnecessary delays
6. Civil justice has been enforced effectively
7. Mechanisms of Alternative Dispute and Resolution (ADR) are reachable, effective, and impartial

1.2.2 Criminal Justice

1. Investigation system of criminals is effective
2. The system of criminal adjudication is effective and does not involve delays
3. The correctional system for criminals is effective and succeeds in mitigating criminal behaviour in society
4. The criminal justice system in the country is unbiased
5. The criminal justice system of the country is corruption-free
6. The criminal justice system does not involve the improper influence of government
7. The country considers due law process and the rights of the accused

1.2.3 Order and Security

1. The country has the ability to control the crime effectively
2. The country has the ability to limit civil conflict effectively
3. The public in the country does not resort to violence for redressing personal grievances

1.2.4 Regulatory Enforcement

1. Government has the ability to enforce its regulations effectively
2. Government has the ability to apply and enforce its regulations without any improper influence
3. Administrative proceedings in the country are conducted without any unnecessary delays
4. The due process involved in administrative proceedings is respected
5. The Government does not expropriate without adequate compensation

1.2.5 Absence of Corruption

1. Government officials belonging to the executive branch prohibit using public office for private gain
2. Government officials belonging to the judicial branch avoid prohibiting using public office for private gain
3. Government officials belonging to police and the military prohibit using public office for private gain
4. Government officials belonging to the legislative branch prohibit using public office for private gain

1.2.6 Open Government

1. Data related to laws and government is publicly available in the country

2. The public can request information related to the government and the government grants the requested information in a timely manner
3. The government protects the freedom of opinion and expression of the public
4. Effectiveness of the complaining mechanism against government officers

1.2.7 Constraints on Powers of Government

1. Powers of government are being monitored by the legislative bodies effectively
2. The judicial system of the country is independent and has the ability to keep a check on the powers of government
3. Auditors and controllers are independent enough to have a check on government
4. Institutions of the country are independent to investigate, prosecute, and punish officials of government for misconduct
5. Media, civil society, political parties, and the public is independent to report and criticize the government policies

1.2.8 Fundamental Rights

1. The country is free of discrimination on the basis of sex, gender, ethnicity, religion, and socio-economic status with respect to employment, public service, and the justice system
2. The country guarantees life rights and security to the individuals belonging to political parties and media
3. The country protects the rights of criminal suspects and provides them adequate legal assistance
4. The country offers freedom to media, civil society, members of political parties, and the general public to criticize policies of the government without fearing retaliation
5. The country provides the freedom to minorities to worship as per the requirement of their religion

6. The country ensures that police and other security agencies conduct a physical search as per legal authorization

7. The country ensures that people have the freedom to join communities and political parties and they have freedom of expression

8. The country ensures the fundamental rights of labour and equal employment opportunities

1.2.9 Informal Justice

1. The country provides informal justice in an efficient and timely manner

2. The country ensures that informal justice is free of inadequate influence

3. The country guarantees that informal justice protects the fundamental rights of people

1.3 Problem Statement

A high volume of pending lawsuits is an important issue of the country. According to the data of the Supreme Court of Pakistan as of 1st June 2018, there were 40091 pending cases held with various branches of the Supreme Court of Pakistan [38]. The data of Lahore High Court states that there were 181999 pending cases held with various benches of Lahore High Court in the year 2019 [36]. This results in a lack of trust on the justice system of the country among the general public and eventually causes the low rank in the WJP. Two main issues of the justice system of Pakistan include:

1. A large number of pending cases

2. Unnecessary delay in the implementation of the decisions of honourable courts

The primary cause of the large volume of pending cases and delays in the implementation of the court's decision is the lack of a system that can help to monitor the progress of registered cases. Apart from that, past judgments are used as references in the current cases. That's why legal professionals spend a significant amount of time reading past judgments. The majority of the time, they find that the judgments they were reading

were irrelevant. This results in a waste of time and energy. So we can say that there is a dire need to have:

1. A system than can help the judicial system to monitor the progress of registered lawsuits
2. A system that can help legal practitioners to shortlist judgment(s) of interest

1.4 Research Objective

This study intends to improve the effectiveness of the country's justice system using data analytics. The proposed solution has been divided into two parts.

1. The first part of the solution is a legal dashboard that will provide insights into the status of all registered lawsuits. The dashboard will present information about:
   (a) Registered lawsuits with respect to the court, assigned judge, timeframe, and type
   (b) The average duration of pending and resolved lawsuits
   (c) Implementation status of the judgments with respect to the court, assigned judge, timeframe, and lawsuits type
2. Reading past judgments is a time-consuming task and involves a significant amount of effort. The second part of the solution will help legal practitioners to extract the main topics from the past judgment(s). This will help them to find whether judgment(s) is of their interest or not. This will save a significant amount of time and energy that might be spent on reading a large number of irrelevant judgments.

1.5 Key Contributions

The IT sector in the country is not yet mature enough. That's why the implementation of IT in the judicial system has not been done so far. Our study is the first study of its kind. We had multiple meetings and discussions with the officials from the Supreme Court of Pakistan and then on the basis of their input, we proposed a legal dashboard that will help monitor the performance of the justice system in the country. Apart

from that, the application of the text mining technique to identify the content of the judgments of Pakistani courts is also a new concept.

1.6 Organization of the Upcoming Chapters

The rest of the thesis has been organized into three chapters. Chapter 2 of the thesis will discuss existing literature on the application of Information Technology in the legal domain, the application of data analytics in decision-making/performance monitoring, and the application of data analytics in text mining. Chapter 3 will discuss the implementation and subjective evaluation of the proposed solution. Chapter 4 will conclude the thesis and will state the future work direction and limitations of the study.

Chapter 2

Literature Review

This section will discuss some of the past studies on the application of data analytics in the legal domain. A small amount of studies were found in this domain. So, we divided this section into three sub-sections i.e., literature review on the application of IT in the legal domain, literature review on data analytics, and literature review on text mining.

2.1 Information Technology and the legal domain

The application of Information Technology (IT) in the legal domain has been a hot research topic for decades [18]. Different areas of IT have successfully been implemented in the legal domain globally. Some of the significant areas of IT that have been used in the legal domain include machine learning, deep learning, information retrieval, Natural Language Processing (NLP), data analytics, etc. This section will discuss existing literature on the application of these areas in the legal domain.

The study [19] employed a deep learning model combined with natural language processing techniques for the classification of sentences of rhetorical type. The researchers used an open-source repository comprising 6153 sentences and divided it into two parts i.e., the training set and the test set. The training set contained 85% of the data whereas the test set contained 15% of the data. Then they defined sentences into different rhetorical types, which include sentence, finding sentence, reasoning sentence, evidence sentence, legal rule sentence, and citation sentence. The used Bi-directional LSTM model for classification purposes and compared its performance with SVM, which was used in a previous study. They used precision, recall, and F1 score for evaluating the perfor-

mance of the deep learning model. The bi-directional LSTM model outperformed SVM for classifying sentences of rhetorical types.

The study [18] proposed a classification method for retrieving legal texts on the basis of feature words. In the first step, the researchers analyzed the linguistic features of legal documents, which were in the English language. They used wording and syntactic features for analyzing the text of legal documents. Then they designed an algorithm that processes and analyzes documents through text processing i.e., stop words removal and keywords extraction, and legal dictionary segmentation. Then the algorithm acquires 20 keywords of each case through TF-IDF and finally, the feature words are obtained. They used the SVM algorithm for the classification of legal text and evaluated results using precision and recall. The significant contribution of researchers includes the incorporation of chi-square statistic into TF-IDF and the introduction of a position factor for feature words.

The study [17] discussed the application of Convolutional Neural Networks (CNN) for the classification of legal text. The researchers used four confidential datasets comprising legal matters on social media, communication, security, and education. The first dataset comprised 410,954 documents, the second dataset comprised 1,570,956 documents, the third dataset comprised 492,318 documents, and the fourth dataset comprised 308,738 documents. They selected 100,000 labeled documents at random and divided them into training set and test set. The test set comprised 10,000 documents. Then they applied text pre-processing techniques i.e., tokenization, token filtering, stemming, N-gram generation, and feature selection to the selected dataset. Then they applied CNN, SVM, logistic regression, and random forest techniques and evaluated their performance using precision and recall. CNN outperformed all other algorithms with a precision rate of 75% for classifying legal text.

The study [29] aimed to compare the performance of legal text summarization approaches. The researchers used an open-source dataset "BillSum" for experimentation and used Python language for experimentation purposes. In the first step, they performed preprocessing to the dataset, which include data normalization, removal of semi-colons, white spaces, and any special characters. In the second step, they applied text summarization algorithms which include Textrank, Lexrank, Edmunsun, Luhn, LSA, and Sumbasic. Then they used Rouge, BLEU, and cosine similarity algorithms

for evaluating text summaries. Results indicated that graph-based text summarization techniques outperformed all other techniques.

The study [21] proposed an AI-based legal assistant for helping legal experts with various legal situations. In the first step, the researchers pre-processed the dataset, which includes stop words removal, stemming, lemmatization, and POS tagging. Then they used Word2vec and Doc2vec techniques for finding text similarity. After that, they found rank scores between case segments of the same type and stored the information in the knowledge base. Then they build an ontology-based question answering engine, which was responsible for finding a contextual summary of the questions. In the next step, the contextual summary is fed to an AI-based bot, which converts speech to text and text to speech and helps the legal experts with various legal situations on the basis of past judgments.

The study [25] discussed the application of supervised machine learning techniques for classifying writing styles of German legal text on the basis of argumentation mining. The researchers acquired a publicly available corpus comprising 11,477 judgements. Then they randomly selected 200 judgements for annotation and trained a model for the classification and subsumption of various definitions in the judgements. Then they detected argumentative text in the judgements. The argumentative text includes unigrams, bigrams, trigrams, verbs, adverbs, modal auxiliary, word couples, text statistics, punctuation sequence, keywords, and phrase features. They used the maximum entropy model, multinomial naïve Bayes classifier and SVM for the classification of writing styles of German legal text. It was found that the statistical classifiers i.e., maximum entropy model and multinomial naïve Bayes classifier outperformed SVM.

The study [5] discussed the application of business analytics in legal decision-making using past judgments in real-time. The researchers proposed a graph-based approach, where they assigned weights to different attributes of the judgment. They took input on the weightage of attributes from judges and proposed a novel tool for judges to analyze new cases on the basis of past judgments in the relevant area.

In [8] the researchers proposed a GUI-based meta-search system for searching previously asked questions on the proceedings of the court. They took two documents comprising 806 proceedings of Indian court and legal forum and indexed them with the system. The proposed system was built using Java, JSP, Servlet, HTML, and CSS. They used

a combination of the Inverse Document Frequency model with Laplace after-effect and normalization and Divergence from Randomness model. The evaluation indicated that the performance of the model was satisfactory.

The study [2] evaluated the trust level of internal users of the Turkish judiciary on UYAP. The UYAP is an e-justice system, which was built to ensure an efficient, reliable, soundly operated, and accurate judicial system in Turkey. Ministry of Justice, General Directorate of Information Technologies designed a questionnaire and sent it to 8840 internal users of UYAP. Out of 8840 internal users, 593 were chief judges, judges, attorneys general, and solicitors. The researchers used the Likelihood Ratio and Pearson Chi-square test for measuring the association of trust level. It was found that there is a negative relationship between age and trust. The trust level decreases as the age of the internal user increases.

In [3], the researchers proposed an ICT-based court monitoring system, which aimed to improve the effectiveness of the monitoring of lower courts by improving the efficiency, security, and transparency of the processes in lower courts of Pakistan. They took data from the docket comprising 500 cases. Out of these 500 cases, they randomly selected 200 cases for training purposes and connected them to the system. The proposed system was a web-based client-server application, which was built using PHP and MySQL database with client-side scripting done through JQuery. It was found that the major cause of delay within the lower courts is the lack of an effective monitoring system. The researchers argued that a court automation system must come with an effective data filtering mechanism.

Table 2.1 shows the summary of the reviewed papers on the application of IT in the legal domain.

After reviewing some of the studies on the application of IT in the legal domain, it is found that the majority of the studies were focused on the classification of legal texts, and some of the studies proposed a legal decision-making system for judges. The majority of the studies were published by Western countries and a few of the studies were from India. Since the implementation of IT in the legal domain is not yet mature enough in Pakistan. Hence none of these studies shall meet our requirements. The authors in [3] pointed out the major cause of delay within the lower courts is the lack of an effective monitoring system, so an analytics-based monitoring system will be a good solution to

Table 2.1: Summary of reviewed papers on the application of IT in the legal domain

Author and Publication Year	Country	Purpose	Dataset	Method/Technique
S. R. Ahmad, D. Harris and I. Sahibzada (2020)	Pakistan	Text Classification	open-source data "Veteran Claims"	Bi-directional LSTM, Accuracy Precision, Recall, F-1 Score
Zhonghao Li (2019)	China	Text Classification	English Wikipedia Corpus	Support Vector Machine (SVM), Chi-square, TF-IDF
Robert K et al. (2019)	USA	Text Classification	Four datasets on legal matters	Convolutional Neural Networks (CNN)
Deepali J. et al. (2021)	India	Text Summarization	Legal documents "BillSum Dataset"	Gisting Evaluation metrics (ROUGE), Bilingual evaluation understudy metrics (BLEU), Cosine Similarity
Nishant J. and Gaurav G. (2020)	India	Virtual Legal Assistant (VLA)	Past Judgments	Semantic networks, Ontologies, Question generation engine
Stefanie U. et al. (2020)	Germany	Text Classification	Open source court decisions of the Bavarian state	Maximum entropy model, Multinomial naïve Bayes classifier
Luis Raul Rodrıguez Oconitrillo and Alvaro de la Ossa Osegueda (2016)	Republic of Costa Rica	Legal reasoning tool for judges	Legal cases	Business Intelligence (BI) Model
Ambedkar K. (2017)	India	Meta Search System	Proceedings of Indian court and legal forum	Java, JSP, Servlet, HTML, CSS, Inverse Document Frequency model Divergence from Randomness model
Ozlem O. et al. (2013)	Turkey	Evaluating trust level on "UYAP" e-justice system	Response collected through questionnaire	Likelihood Ratio, Pearson Chi-square test
Amn Rahman et al. (2014)	Pakistan	ICT-based Court Monitoring System	Case files, Judgments	PHP, MySQL with client-side scripting

the problem.

2.2 Data Analytics

Data analytics is one of the most popular research areas in the field of computer science. It helps organizations provide insights into their Key Performance Indicators (KPIs), which are easy to understand. On the basis of insights, organizations devise strategies to improve their weak areas and further strengthen the strong areas. There are various analytics-based solutions that can help organizations to monitor their performance and devise strategies for tackling identified problem areas.

The study [34] used data analytics to justify the accuracy of the decision-making of higher management on creating value proposition in the university environment in Ukraine. The value proposition defines the university's competitive advantage, requests of the labor market, and different stakeholders. The overall solution was based on Big Data, statistical data models, and Power BI visualizations. The researchers loaded data in Power BI from different databases and visualized different educational services in the market, different educational programs with respect to applicants, entrants, graduates, etc., and price determination policies of different Higher Education Institutions (HEIs). Power BI provided great support in visualizing large datasets, sorting, filtering, linking different arrays, and comparing the results visually.

Data analytics has a good application in construction project management. The study [35] used Power BI for monitoring the progress of 13 real-world Engineering, Procurement, and Construction projects in Qatar. The researchers identified Key Performance Indicators (KPIs), which include schedule status, cost status, safety status, quality status, and overall project performance. After identifying the KPIs, they connected the database to Power BI and visualized the core KPIs for evaluating project progress. The proposed dashboard presented the summary of overall project performance, the performance of the contractor, performance of the project, project variance, and expected date of project completion, which helped the higher management in effective decision-making. The proposed solution was a combination of descriptive data analytics, data mining techniques, and Power BI, where Power BI was the core component and provided interactive visualizations of the data insights.

Data analytics has a great application in the insurance sector. The study [23] used Power BI for designing a dashboard, which effectively provided insights into insurance contracts and different factors of insurance portfolios in real-time. The researchers connected the database of insurance contracts with Power BI and visualized important factors of insurance data, which include total gross premiums, total gross claims on insurance portfolios, total gross claims, total return premiums of terminations, and date-wise insurance activities. The proposed dashboard proved to be very helpful in monitoring technical risks associated with insurance activities and provided in-depth analytics.

A large number of organizations used data analytics to measure their performance. The study [32] was a case study of a metal-based part manufacturing SME. The researchers interviewed different stakeholders of the SME, which include the head engineer, purchasing admin, accounting, PPIC admin, production head, quality control head, raw material warehouse head, and finished goods warehouse head. They used Integration Definition for Process Modelling (IDEF0) for the identifying relationship between different activities. In this step, they identified metrics of production, productivity, and defect and prepared data in Excel. Then they designed five dashboards using Power BI. The first dashboard provided insights into sales and marketing data. The second dashboard provided insights into the production of the SME. The third dashboard provided insights into the raw material. The fourth dashboard provided insights into purchase and warehouse, and the fifth dashboard was the main dashboard, which was built by combining all four dashboards. The researchers used powerful visualizations and data filtering functions of the Power BI tool, which helped the higher management of the SME to monitor the performance and devise a strategy for increasing productivity.

The study [20] discussed the application of data analytics and machine learning in Human Resource Management (HRM). The researchers took the dataset of the Human Resource of IBM, loaded it in Power BI, cleaned it, and applied Principle Component Analysis (PCA) to it. After that, they performed feature extraction on it. Then they divided the data set into two parts i.e., test set and training set, and applied two machine learning algorithms i.e., logistic regression and random forest on it. After that, they evaluated the trained set on the basis of the test set and measured the performance of the algorithms using accuracy, F-1 score, precision, and recall. Results indicated that Random Forest outperformed the logistic regression. Finally, they connected the Ran-

dom Forest to Power BI and created a dashboard. Power BI effectively visualized actual employee attrition rate, predicted employee attrition rate, promotion rate, employee satisfaction rate, employees left the company, and work accidents during the last five years. The proposed dashboard provided insights into Human Resource Management to higher management, and they improved their HR practices, which helped in the retention of experienced employees.

The study [11] used Latent Semantic Analysis (LSA), and data analytics to perform a comprehensive analysis of the CSR data of L&T Infotech. The researchers prepared a Model View Controller (MVC), where NLP and Power BI acted as models, Graphical User Interface (GUI) and interactive visualizations acted as views, and a combination of NLP and Power BI acted as controller. In the first step, the researchers obtained the CSR reports of the company from 2013 to 2016, which were text files. Then they used python language to apply Natural Language Processing (NLP) techniques to the text file. They pre-processed the data i.e., removed stop words and did lemmatization, and then applied LSA. After that, they loaded CSR data into an MS Excel sheet, loaded the Excel sheet into Power BI, checked and linked different entities as per requirement, created suitable visualizations, and published them online. The proposed dashboard included the number of beneficiaries, number of centers, number of locations, budget, the amount spent, and skill types. The proposed dashboard helped the company to assess its performance and compare them with its counterparts and devise a good business strategy.

The study [28] discussed the application of data analytics in an IIoT-based solution for predictive monitoring on the basis of vibration data from motors. The researchers developed a vibration data acquisition devise, which has four input channels and sends the acquired data to the Azure storage account. They connected a microcontroller (STM32F446RE) to the input channel for processing the data, A Bluetooth module (HC-06) was responsible for managing communication with Human-Machine Interface (HMI). The HMI was a mobile application, which acted as an intermediary between the users and the platform. The researchers used the Azure machine learning studio for the implementation of machine learning techniques. In the first step, they performed preprocessing of the dataset. Then they divided the dataset into two parts i.e., the training set and the test set. After that, they trained different machine learning models, which include averaged perceptron, locally-deep SVM, Bayes point machine, boosted

decision tree, decision jungle, decision forest, neural network, logistic regression, and Support Vector Machine (SVM). Then, they used accuracy, confusion matrix, and F-1 score for evaluation of the machine learning models. Results indicated that decision forests outperformed all other models. Finally, the results of decision forests were given to Power BI for generating a report.

The study [26] discussed the application of data analytics to analyze Twitter data of a higher education institution in Portugal. In the first step, researchers created an app in the Twitter developer. They submitted a request to Twitter that they need a Twitter developer account for the extraction of Tweets for academic research purposes, which was granted by Twitter only for seven days. They extracted the data of Tweets using Advanced Editor of Power BI. They used six parameters i.e., "ISCAC", “Institute of Accounting and Administration of Coimbra", “iscac”, “CBS” "Higher Institute of Accounting and Coimbra Administration”, and “Coimbra Business School “ for extracting Tweets. Then they selected information of their interest and eliminated irrelevant information. Then they used the DAX function to load data into Power BI. After that, they created bar charts, which showed the number of Tweets made per hour, per day, and per week. A large number of Tweets were made between 1 to 2 PM, which indicates that students make Tweets during the break time. If we look at the number of Tweets by day, it was found that the majority of the Tweets were made on weekends. Apart from that, they used different filters in the dashboard to see the information of their interest such as comments in Portuguese, English, Hungarian, and Czech. It was found that there were many comments in English, Hungarian, and Czech, which indicates that higher education contains students studying in the Erasmus Mobility program. Power BI provided great visualizations, which helped in finding important information about the higher education institution.

The study [33] discussed the application of data analytics to visualize the allocation of European Union (EU) funds in Portugal. Prioritized sectors for the allocation of funds under the Portugal 2020 program include competitiveness and internationalization, social inclusion and employment, human capital and sustainability, and efficient utilization of resources. The researchers extracted the dataset in MS Excel format from the official website of the Portugal 2020 program. In the first step, they performed ETL on the dataset using the Power Query function in Power BI. After that, they designed three dashboards, the first dashboard included total funds, average effective co-financing rate

of projects, and average duration in days by thematic objective, data can be filtered by thematic objective. The second dashboard included total funds, the number of approved projects, and the number of companies (county-wise). It was found that Funchal had the highest number of projects (3408) and Porto Moniz had the smallest number of projects (50). The third dashboard included the total amount of funds received per year, the number of approved projects per year, and the category of funds with respect to project and amount. The Power BI effectively handled the huge dataset of the program. Apart from that, powerful visualizations of Power BI made it easy for the higher management to understand the distribution and utilization of EU funds. It was evident from the analysis that EU funds played a pivotal role in boosting the economy of Portugal.

The study [13] discussed the application of data analytics to analyze and develop a dashboard for SMEs in Thailand. The researchers randomly selected 40 SMEs related to the service and production sector from the database of the government. They collected data from ERP, Human Resources, CRM, sales, and operations. In the first step, they cleaned the data using the Power BI desktop. After that, they designed three dashboard templates for sales. The sales dashboard showed the amount spent on the purchase, the amount generated through sales, stock by product category, month-wise sales, customer-wise sales, and top three customers. The second dashboard showed the sales and quantity of stock. Whereas the third dashboard showed the proportion of customer-wise sales and purchases. The designed dashboards were shared with SMEs, which used them for 6-9 months and after that, they evaluated the effectiveness of the dashboards. According to the SMEs, dashboards were interactive and easy to understand for individuals without a technical background. This helped them in reducing costs, saving time, and decision-making about the business in a better way.

The study [27] discussed the application of data analytics to visualize air quality data in South Africa. The researchers collected the air quality data from the year 2013 to 2018 from three stations of the Rustenburg Quality Monitoring Network. The dataset is comprised of data with hourly and daily intervals. They cleaned the dataset and performed other data quality measures in MS Excel. Then, they imported data into Power BI for designing a dashboard. Powerful visualizations of Power BI helped in identifying the regions with low and high-quality air for the last six years. It helped in identifying the regions, which need attention, and policy-making was done accordingly.

The study [10] discussed the application of data analytics to design personalized dashboards for the students of Stenden University of Applied Sciences, Netherlands. The university has a Student Information System (SIS), which tracks the academic performance of the students. The SIS provides an overview of the results to students, which is very basic and cannot help them in tracking their performance effectively. In such a situation, there was a dire need to have a system that could help students in tracking their educational performance through visualizations. In this context, the researchers designed individualized dashboards for students using Power BI. They loaded data into Power BI through SIS and used the Power Query function for data transformation. The dashboards effectively provided insights into the performance of the students in real-time. Students were able to see passed courses, course-wise percentage, completed and pending credit hours, achieved CGPS, highest GPA, and study duration graphically. This helped them in monitoring their performance and the performance of their peers as well, which resulted in improved results.

Table 2.2 shows the summary of the reviewed articles on the application of data analytics in different sectors. It is evident from the reviewed literature that data analytics can help measure the performance of large organizations. It has successfully been employed in different sectors of the economy worldwide, and it provides insights into the data in the form of powerful visualizations that are easy to understand and help in effective decision-making. It can be used to measure the performance of the judicial system of the country and improve its effectiveness.

2.3 Text Mining

Text mining is one of the hottest research topics in the area of Natural Language Processing (NLP). A large number of studies have been published in this area. This section will discuss some of the studies on text mining.

In [16], the researchers discussed the implementation of two topic modeling techniques on a corpus of newspapers and compared their performance. They acquired an open-source corpus comprising 22675 Bangla news articles and divided them into 9 categories such as accident, crime, entertainment, international, politics, science, sports, weather, etc. In the first step, they performed preprocessing to the dataset which include tokenization, stop words removal, and lemmatization. In the second step, they implemented LDA

Table 2.2: Summary of reviewed papers on the application of data analytics

Author and Publication Year	Country	Purpose	Dataset	Method/Technique/Tool
Larysa S. et al. (2021)	Ukraine	To ensure the correctness of management decisions on value proposition creation	Official data of university	MS Power BI
Ahmed Al-Sulaiti et al. (2021)	Qatar	Performance evaluation of construction project	Data of 13 different EPC projects	MS Power BI
Ryszard Pukala et al. (2020)	Poland	Monitoring of Insurance Activity	Insurance Portfolios	MS Power BI
Elia Oey et al. (2021)	Indonesia	Performance evaluation of SME	Sales, purchase, Marketing, and production data of company	MS Power BI
Mohammed Ameer et al. (2020)	India	HRM predictive analytics	IBM employee dataset	MS Power BI, Logistics Regression, Random Forest, accuracy, precision, recall, and F1-score
C.V Sneha et al. (2017)	India	Analysis of CSR data	Internal LT CSR data	LSA, MS Power BI
Ravi Helon et al. (2021)	Brazil	Predictive monitoring	Educational dataset	Microsoft Azure machine learning, F1-Score, MS Power BI
Bruno Varela et al. (2020)	Portugal	Twitter Sensitivity Analysis	Twitter data of a higher education institution	MS Power BI
Diogo Pimenta et al. (2021)	Portugal	To monitor the allocation of European funds	EU funds dataset	MS Power BI
Wasinee Noonpakdee et al. (2018)	Thailand	To analyse and develop dashboard templates	SME's ERP, CRM, HR, Sale, and operation data	MS Power BI
Caradee Y. W. and Bianca W. (2020)	South Africa	To visualize air quality data	Particulate Matte (PM) dataset (2013-2018)	MS Power BI
J. Sluijter and M. Otten (2017)	Netherlands	To develop personal KPIs of each student	Data of students (2009-2016)	MS Power BI

and LDA2Vec methods on the news article dataset. LDA yielded an accuracy rate of 62.45% whereas LDA2Vec yielded an accuracy of 85.66%.

The study [4] compared the performance of LDA and GSDMM on short text. The researchers acquired three open-source corpora. One corpus comprised 495 news articles, whereas the other two corpora comprised 77946 tweets about weather and 15984 tweets about the GOP debate. In the first step, they performed preprocessing to the dataset which include removal of stop words, removal of special characters, removal of less frequent words, and lemmatization. In the second step, they implemented LDA and GSDMM in Python language. They used coherence and stability for evaluating the performance of the models. The performance of LDA was slightly better than GSDMM in the case of news articles. Whereas in the case of short text, GSDMM outperformed

the LDA model.

The study [14] discussed the application of NMF and LDA topic modeling of crime reports in Los Angeles. The researchers acquired a publicly available dataset comprising crime reports from 2009 to 2014. In the first step, they performed preprocessing to the dataset which includes stop words removal and removal of words with length less than three characters. After that, they processed the document term matrix using TFIDF weighting factors so that the most frequent words could be emphasized. Then they implemented NMF and LDA model with k = 7, where k is the number of topics. They implemented topic models using Python and used coherence and Gini index to evaluate the models. It was found that LDA has higher coherence and Gini index as compared to NMF.

In [9], the researchers discussed the application of the LDA model for finding different trends in the technical knowledge domain. They used BeautifulSoup, a python library, and mined 1,070 articles in the area of information security. In the first step, they performed preprocessing of the articles. The preprocessing includes removal of source code fragments, conversion of text to lower case, tokenization, stop words removal, and lemmatization. Then they implemented two LDA models using python language. In the first model, they employed the number of unique categories from the corpus. In the second model, they employed the number of topics suggested by mountain clustering. Finally, they evaluated models on the basis of perplexity score.

The study [6] discussed some of the significant topic modeling techniques and tools. The study elaborated on topic modeling and different steps involved in implementing topic models i.e., bag of words, model training, and the output. The topic modeling techniques covered in this study include VSM, LSI, PLSI, and LDA. The researchers discussed various topic modeling tools which include Gensim library, MALLET, TMT, and BigARTM. The researchers discussed that the first step in topic modeling is preprocessing of the corpus. The major preprocessing techniques include stop words removal, tokenization, and stemming. After preprocessing, a collection of words also known as vocabulary or dictionary was acquired and then a term-document matrix was created. Finally, they applied topic models to the term-document matrix. The researchers indicated that topic models have been applied in information filtering, people matching on the basis of reviews written by them, image retrieval, text categorization, and automatic

question recommendation. They also mentioned that in VSM, cosine similarity might produce incorrect results due to noise. LSI model is dependent on SVD, which results in the usage of more computing power. PSLI cannot handle a large number of documents since the more will be the number of documents the more will be the parameters.

In [12], the researchers proposed a ProjectRank model combining LDA with a topic evaluation method. They targeted several websites and acquired Chinese news data from January to April 2016 using WebCrawler. The news data comprised news title, news content, news source, related images, links, and time. They imported the news data into a database and performed preprocessing to the dataset. The preprocessing includes stop words removal and removal of words with low frequency. After that, they implemented the LDA model taking news data as input. Finally, they formed the ProjectRank model and evaluated the extracted topics.

The study [24] applied LDA to research data in Thailand and found research topics, which were further used for devising the national research strategy. The researchers acquired 5480 research papers over 12 years i.e., from 2008 to 2019 in different research areas of the National Research Council of Thailand (NRCT). In the first step, they extracted abstracts from all the research papers. Since the research papers were in different formats such as doc, pdf, jpg, etc. hence they used Optical Character Recognition (OCR) for this purpose. Due to the usage of OCR, some of the words were concatenated. In the second step, they split the concatenated words and performed preprocessing to the content of the abstract. The preprocessing includes stop words removal, tokenization, removal of words with low frequency, conversion of content to lower case, and lemmatization using Spacy, a python library. After that, they categorized abstracts into 7 academic tracks and built a dictionary using the words of all of the abstracts. Finally, they implemented LDA to the finalized dataset using 5 to 50 topics. They used coherence and perplexity to evaluate the appropriate number of topics.

The study [15] discussed the application of topic modeling techniques to Urdu text documents. The researchers formed four corpora comprising news articles, news forums, and news websites in the Urdu language. The first corpus comprised sports articles, which were acquired from the official website of BBC Urdu. The second corpus comprised political news articles, which were acquired from urdupoint.com. The third corpus comprised entertainment articles, which were acquired from the official website of the Express

newspaper. Whereas the fourth corpus comprised articles on the economy, which were acquired from all aforementioned sources. In the first step, they performed preprocessing to the dataset. The preprocessing includes the removal of diacritics, removal of stop words, tokenization, and stemming. Finally, they implemented Variational Bayes (VB) based LDA for Urdu (VB-ULDA) with and without stemmer. It was found that LDA for Urdu (VB-ULDA) with stemmer performs better than LDA for Urdu (VB-ULDA) without stemmer. Apart from that, the performance of LDA for Urdu (VB-ULDA) with stemmer was compared with simple LDA and Gibbs Sampling (GS) ULDA where LDA for Urdu (VB-ULDA) with stemmer outperformed both of the models in terms of performance and accuracy.

In [22], the researchers implemented topic modeling techniques on the judgments of the Czech Supreme Court. The researchers acquired 111187 judgments of the Czech Supreme Court from January 1994 to September 2018. In the first step, they performed preprocessing to the corpus. The preprocessing includes removal of stop words, removal of numbers and punctuations, removal of less frequent words, lemmatization, and conversion of all words to lowercase. Apart from that, they used POS tagging to identify nouns and pronouns. Preprocessing was done using Spacy, a python library. In the second step, they implemented LDA and NMF techniques using the genism library. They tried 10, 20, 30, 40, 50, 60, 70, 80, 90, and 100 topics and evaluated LDA and NMF using coherence. It was found that the NMF model is better than LDA.

Table 2.3 shows the summary of the reviewed papers on the application of text mining. The majority of the studies discussed in this section focused on the implementation of topic modeling techniques in short texts. [16, 4, 14, 12, 15] implemented news topic modeling techniques on tweets and online news articles. There are very few studies that have discussed the implementation of topic modeling techniques on large text documents such as court judgments. The researchers [22], implemented LDA and NMF on court judgments. However, the study targeted only two models. The study [6] discussed various topic modeling techniques which are expected to perform well on long texts. The performance of other topic modeling techniques for large texts can be evaluated. The majority of the studies used coherence for the performance evaluation of topic models.

Table 2.3: Summary of reviewed papers on the application of text mining

Author and Publication Year	Country	Purpose	Dataset	Method/Technique
Md. Hasan et al. (2019)	Bangladesh	Performance comparison	Online Bangla news documents (Long text)	LDA, lda2vec, Accuracy Rate
Jocelyn Mazarura and Alta de Waal (2016)	South Africa	Performance comparison	Tweets dataset (Short text)	LDA, GSDMM, Coherence
Ritika Pandey and George O. Mohler (2018)	United States	Evaluation of topic models	Dataset of crime incidents in Los Angeles	LDA, NMF, Coherence
Alexey P. Shiryaev et al. (2017)	Russia	Finding trends in technical knowledge domain	1,070 IT articles	LDA, Perplexity
Bhagyashree V.B et al. (2017)	India	Discussion on topic modelling methods	Not applicable	VSM, LSI, PLSA, LDA
Wenxing Hong et al. (2018)	China	To introduce an Internet Topic Evaluation Model	News data from Jan to Apr 2016	LDA
Nuutthapachr S. et al. (2020)	Thailand	To find trends and themes in research projects dataset	Dataset of Govt funded research projects from 2008-2019	LDA
Anwar Ur Rehman et al. (2018)	Pakistan	Application of topic modelling on Urdu text	Sports articles from BBC Urdu	Variational Bayes LDA
Tereza N. et al. (2020)	Czech Republic	Application of topic modelling on judgments	Judgments of the Czech Supreme Court	LDA, NMF

2.4 Critical Analysis

It is evident from the reviewed literature that modern technologies such as deep learning, machine learning, NLP, data analytics, etc. have been implemented in the legal sector around the globe. Since the IT sector in Pakistan is not yet mature enough, the implementation of the aforementioned technologies in the Pakistani legal system will take time. The primary objective of this study is to propose an analytics-based solution to improve the performance and rank of the justice system in Pakistan. The score of Pakistan in the WJP depends upon many factors, which are directly or indirectly interlinked with the performance of the Pakistani judiciary. The WJP score can be improved by improving the performance of the judiciary. There exist a large number of pending cases with various courts in Pakistan. Apart from that, the implementation of the court's decision also involves huge delays. Currently, the Pakistani judiciary lacks a system that could help in monitoring the status of registered cases and the implementation of decisions. An analytics-based solution can provide insights into the legal performance of various courts in Pakistan, which will play a vital role in improving the performance of the Pakistani judiciary that can improve the rank of Pakistan in

the WJP. Power BI is a powerful data visualization tool that has the ability to handle large datasets. A legal dashboard can be designed using Power BI, the dashboard will provide insights into the performance of the Pakistani judiciary to higher management. Apart from that, past judgments play an important role in current judgments that's why legal practitioners spend a significant amount of time reading past judgments. A topic modeling approach can help identify the main topics of the court's judgment(s). Chapter 3 will discuss the implementation and evaluation of the proposed solution.

Chapter 3

Implementation and Evaluation

The proposed methodology contains two parts. The first part involves a legal dashboard that has been designed using data scraped from the official website of the Supreme court of Pakistan and its sub-courts. Due to the unavailability of complete data, some dummy data was also used for the creation of the legal dashboard. the dashboard shows the summary of the lawsuits registered with various courts i.e., the Supreme Court of Pakistan, Islamabad High Court, Lahore High Court, Sindh High Court, Peshawar High Court, and Balochistan High Court. The proposed dashboard aims to provide an insight into the registered lawsuits to the higher management of the judiciary. This information can be used to assess the performance of the judiciary and devise strategies for improving weak areas. The proposed dashboard was evaluated by legal practitioners and law students of Islamabad-based prominent law schools. A demo of the designed dashboard was given to evaluators and their opinion was acquired using a questionnaire, which can be found in Appendix A. The collected opinion was analyzed statistically using IBM SPSS Version 26.

The second part of the solution involves a text mining technique that will help legal practitioners to find insights into legal judgment(s). We implemented three topic modeling techniques i.e., LDA, LSA, and HDP on a corpus of 10, 100, and 500 judgments. The performance of topic modeling techniques was evaluated on the basis of coherence score.

3.1 Dataset Collection and Preparation

The implementation of Information Communication Technologies in the legal sector in Pakistan has not yet been done. The majority of the lawsuit data is available in hard form. Due to the high volume of lawsuit data, the availability of lawsuit data in digital form will take time. Keeping this in view, the researchers acquired the dataset of past judgments from the official website of the Supreme Court of Pakistan, Islamabad High Court, Lahore High Court, Sindh High Court, Peshawar High Court, and Balochistan High Court. The data was scraped using a python program involving various data scraping libraries such as beautifulsoup4, html5lib, pyparsing, and soup sieve. The scraped data comprised of past judgments in PDF, case id, case number, case subject, law, sublaw, case title, author judge, tagline, citation, date of the announcement, date created, file size in Bytes, appeal case Number, reference cases, and case category. Since the majority of the scraped data is irrelevant for this study so the researchers selected features of interest only.

The dashboard shows information about the registered cases that can be filtered with respect to the name of the court, name of the judge, judgment date, case type, case status i.e., resolved or pending, date of registration of lawsuit, and judgment implementation timeline. Since the acquired dataset belongs to the judgments so we used dummy data to implement the dashboard. The dummy data will be replaced with the actual data at a later stage. The content of PDF judgments was filled out in a CSV file for the implementation of topic modeling techniques.

3.1.1 Data Preprocessing

In this step, we performed preprocessing to the data. It is the primary step of text mining that helps convert unstructured or semi-structured text into an easy-to-understand format. In this step, we removed unwanted content i.e., dashes, punctuations, numbers, and any special characters from the content of judgments and converted the content to lower case. Then we removed stop words from the judgments. The stop words are the words, which don't add any value to the sentences and removing them will not change the meaning of the sentence. Examples of stop words include "a", "is", "the", "are", "my" etc. After that, we tokenized sentences. This step divides sentences into single words. For example, "He is a hardworking person" is a sentence. After applying

tokenization, the output will be “He”, “is”, “a”, “hardworking”, “person”. Then we applied lemmatization to the data. It involves the identification of the root of a word. The root must be meaningful. For example “handling” is a word and after applying lemmatization on it, we will have “handle”, which is its root.

3.2 Legal Dashboard Creation

The legal dashboard was designed using Power BI, a powerful data analytics tool that has the ability to handle large datasets and supports various input files and databases. Figure 3.1 illustrates the proposed legal dashboard.

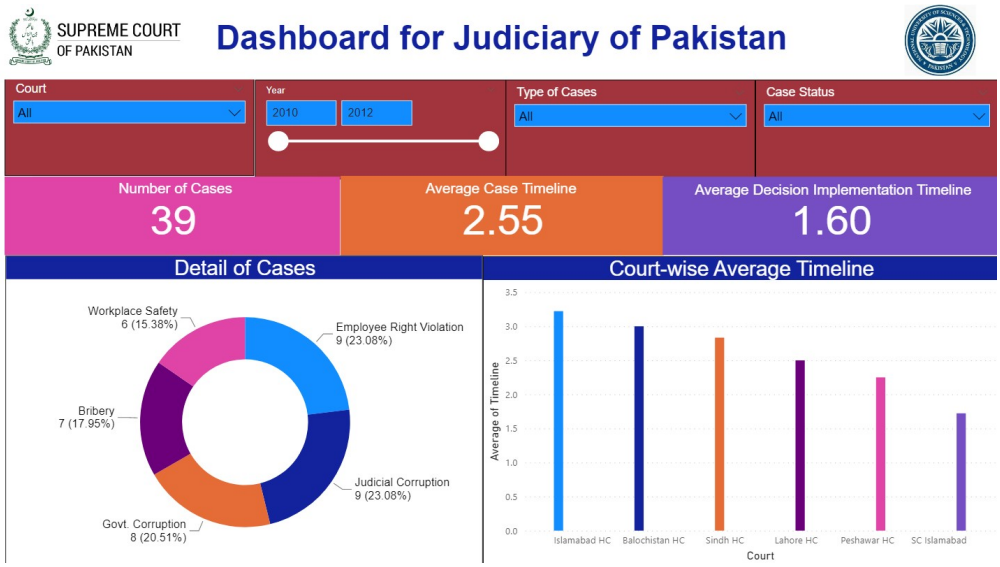

Figure 3.1: Proposed Legal dashboard

The dashboard provides the filter function which has been applied to “Court”, “Year”, “Type of cases”, and “Case status”. Using the filter in “Court”, the users can select the court of their interest amongst all the courts i.e., Supreme Court of Pakistan, Islamabad High Court, Lahore High Court, Sindh High Court, Peshawar High Court, and Balochistan High Court. This will display the information related to that particular court. The filter in “Year” will allow the users to choose the year of their interest and the information regarding lawsuits registered during that year shall be displayed. The filter in “Type of cases” will allow the users to choose the case type of their interest i.e., workplace safety, bribery, Govt. corruption, judicial corruption, employee rights violation. The filter in “Case status” will allow the users to choose the cases of their

interest i.e., resolved and pending cases. The dashboard will display the information related to the case type of users' interest.

The pink-colored card displays the number of total registered cases. Users can see the number of resolved and pending cases using the filter "Case status". The orange-colored card displays the average timeline of registered lawsuits. Users can see the average timeline (in years) of cases in particular "Court", "Year", and "Case type" using filters. The blue-colored card displays the average decision implementation timeline (in years). Users can see the average decision implementation timeline of a particular "Court", "Year", and "Case type" using the aforementioned filters.

The donut chart shows the number and percentage of different types of lawsuits i.e., workplace safety, bribery, Govt. corruption, judicial corruption, employee rights violation. Whereas the bar chart shows the average timeline of registered lawsuits with respect to different courts i.e., the Supreme Court of Pakistan, Islamabad High Court, Lahore High Court, Sindh High Court, Peshawar High Court, and Balochistan High Court.

3.3 Evaluating Legal Dashboard

The proposed legal dashboard was evaluated by legal practitioners and students of prominent law schools in Islamabad. A presentation on the performance of Pakistan in the World Justice Project (WJP) and a live demo of the designed dashboard was given to the evaluators and their opinion on the usefulness of the designed dashboard was collected using a questionnaire comprising Multiple Choice Questions (MCQs). The evaluators were associated with the Faculty of Law at the School of Social Sciences & Humanities (S3H) NUST, Faculty of Law at International Islamic University, and Law Clinic at the School of International Law, Islamabad. A total of 71 individuals participated in the evaluation process. The result of the evaluation will be discussed in this section.

3.3.1 Results of the evaluation

Table 3.1 and figure 3.2 show the age distribution of the evaluators.

It can be seen that out of 71 evaluators, 40 (56.3%) evaluators were aged between 20-30

Table 3.1: Age distribution of evaluators

Age group	Frequency	Percent
20-30 Years	40	56.3
31-40 Years	7	9.9
Under 20 Years	24	33.8
Total	71	100.0

years, 7 (9.9%) evaluators were aged between 31-40 years, and 24 (33.8%) evaluators were aged below 20 years. The majority of the evaluators were aged between 20-30 years.

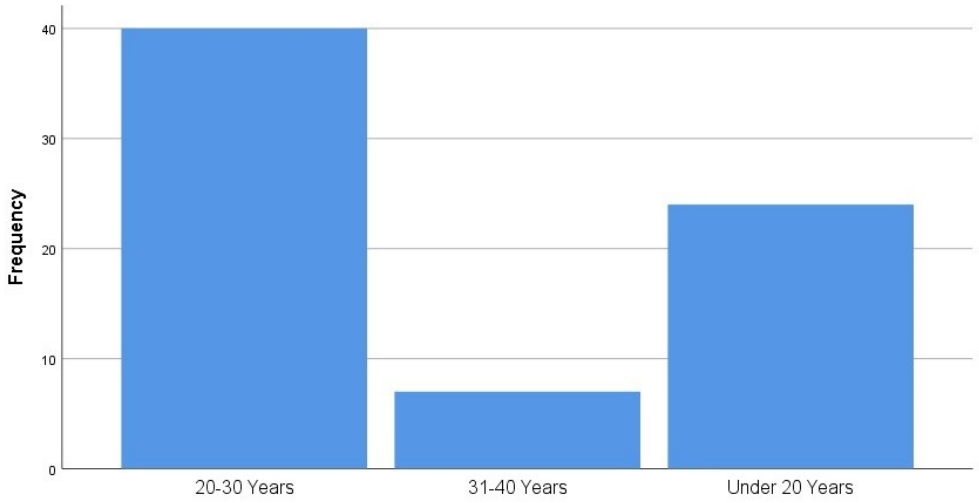

Figure 3.2: Age distribution of Evaluators

Table 3.2 and figure 3.3 show information about the occupation of evaluators.

Table 3.2: Occupation of evaluators

Occupation	Frequency	Percent
Law Students	56	78.9
Lawyers	15	21.1
Total	71	100.0

It can be seen that out of 71 evaluators, 56 (78.9%) evaluators were law students, whereas 15 (21.1%) evaluators were practicing lawyers. The majority of the evaluators were law students.

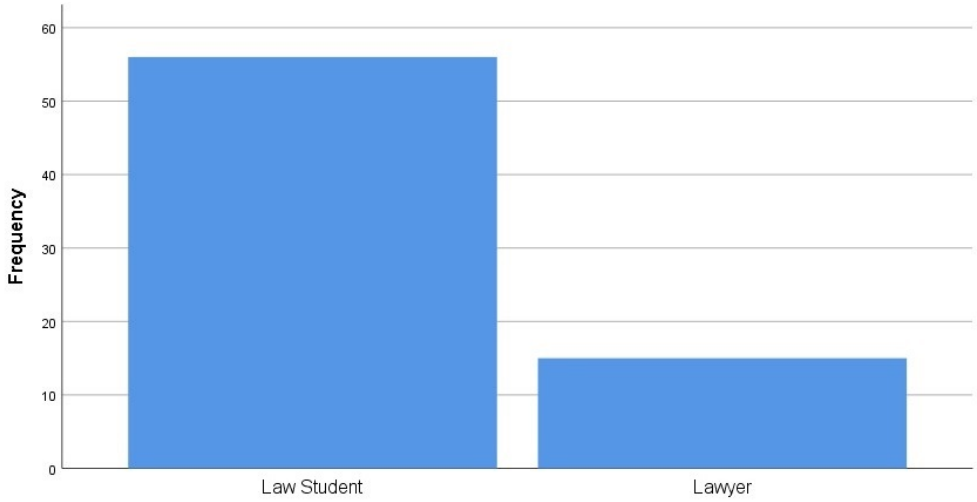

Figure 3.3: Occupation of evaluators

Table 3.3 and figure 3.4 show the comfortability level of the evaluators with using a computer.

Table 3.3: Comfortability level of evaluators with using a computer

Comfortability Level	Frequency	Percent
Comfortable	48	67.6
Somewhat comfortable	8	11.3
Very much comfortable	15	21.1
Total	71	100.0

It can be seen that out of 71 evaluators, 48 (67.6%) evaluators were comfortable with using a computer, 8 (11.3%) evaluators were somewhat comfortable with using a computer, whereas 15 (21.1%) evaluators were very much comfortable with using a computer. The majority of the evaluators were comfortable with using a computer.

Table 3.4 and figure 3.5 show information about the level of familiarity of the evaluators with the World Justice Project (WJP).

It can be seen that out of 71 evaluators, 56 (78.87%) evaluators were law students. Out of which, 17 were familiar with the World Justice Project (WJP), 30 were somewhat familiar with the WJP, 3 were unfamiliar with the WJP, whereas 6 evaluators were very much familiar with the WJP. Out of 71 evaluators, 15 (21.13%) evaluators were practicing lawyers. Out of which, 9 were familiar with the World Justice Project (WJP),

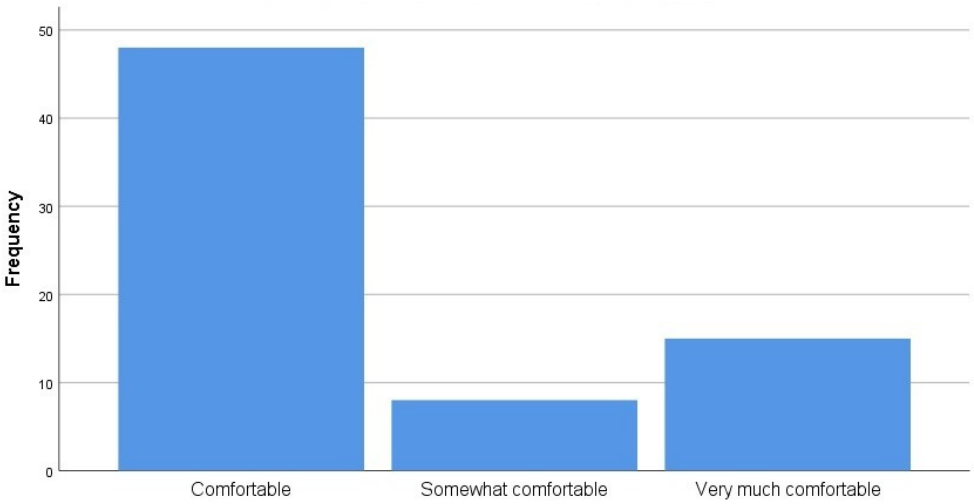

Figure 3.4: Comfortability level of evaluators with using a computer

Table 3.4: Familiarity level of evaluators with the WJP

Familiarity Level	**Law Students**	**Lawyers**
Familiar	17	9
Somewhat familiar	30	6
Unfamiliar	3	0
Very much familiar	6	0
Total	**56**	**15**

whereas 6 were somewhat familiar with the WJP. The majority of the evaluators were somewhat familiar with the WJP.

Table 3.5 and figure 3.6 show that how much the designed dashboard is easy to understand for a layman.

Table 3.5: Understanding level of legal dashboard for a layman

Understanding Level	**Law Students**	**Lawyers**
Easy	35	10
Difficult	4	0
Somewhat easy	6	1
Very much easy	11	4
Total	**56**	**15**

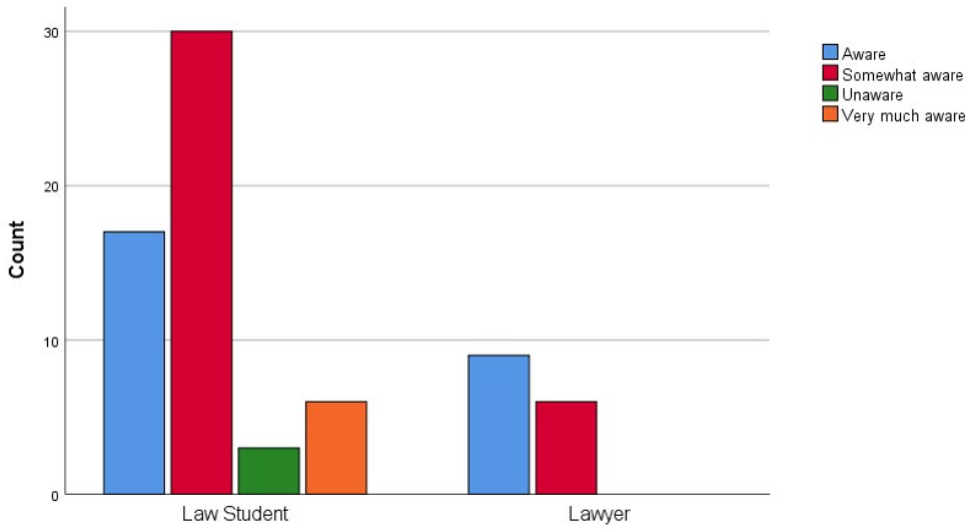

Figure 3.5: Familiarity level of evaluators with the WJP

It can be seen that out of 71 evaluators, 56 (78.87%) evaluators were law students. Out of which, 35 were of the opinion that the proposed dashboard is easy to understand for a layman, 4 were of the opinion that the proposed dashboard is difficult to understand for a layman, 6 were of the opinion that the proposed dashboard is somewhat easy to understand for a layman, whereas 11 were of the opinion that the proposed dashboard is very much easy to understand for a layman. Out of 71 evaluators, 15 evaluators were practicing lawyers. Out of which, 10 were of the opinion that the proposed dashboard is easy to understand for a layman, 1 was of the opinion that the proposed dashboard is somewhat easy to understand for a layman, whereas 4 were of the opinion that the proposed dashboard is very much easy to understand for a layman. The majority of the evaluators were of the view that the proposed dashboard is easy to understand for a layman.

Table 3.6 and figure 3.7 show the effectiveness of the filters used in the proposed legal dashboard.

It can be seen that out of 71 evaluators, 57 (80.3%) evaluators shared that the filters used in the proposed dashboard are effective, 2 (2.8%) evaluators shared that the filters used in the proposed dashboard are ineffective, 3 (4.2%) evaluators shared that the filters used in the proposed dashboard are somewhat effective, whereas 9 (12.7%) evaluators shared that the filters used in the proposed dashboard are very much effective. The majority of the evaluators were of the opinion that the filters used in the proposed dashboard are

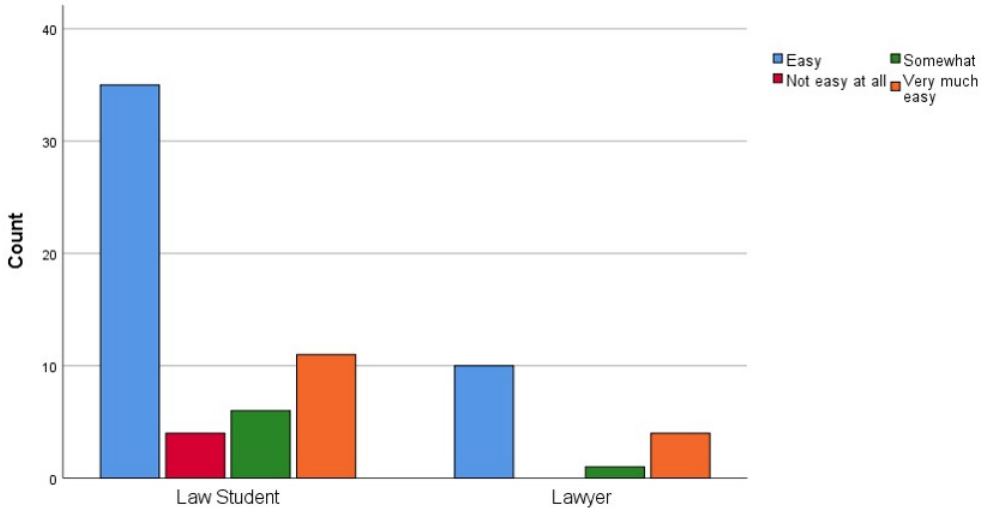

Figure 3.6: Understanding level of legal dashboard for a layman

Table 3.6: Effectiveness of the filters used in the proposed legal dashboard

Effectiveness Level	Frequency	Percent
Effective	57	80.3
Not effective at all	2	2.8
Somewhat effective	3	4.2
Very much effective	9	12.7
Total	71	100.0

effective.

Table 3.7 and figure 3.8 show the effectives of the proposed dashboard for displaying different types of lawsuits.

Table 3.7: Effectiveness of the proposed dashboard to display different lawsuit types

Effectiveness Level	Frequency	Percent
Effectively	59	83.1
Ineffectively	3	4.2
Somewhat effectively	1	1.4
Very much effectively	8	11.3
Total	71	100.0

It can be seen that out of 71 evaluators, 59 (83.1%) evaluators shared that the proposed

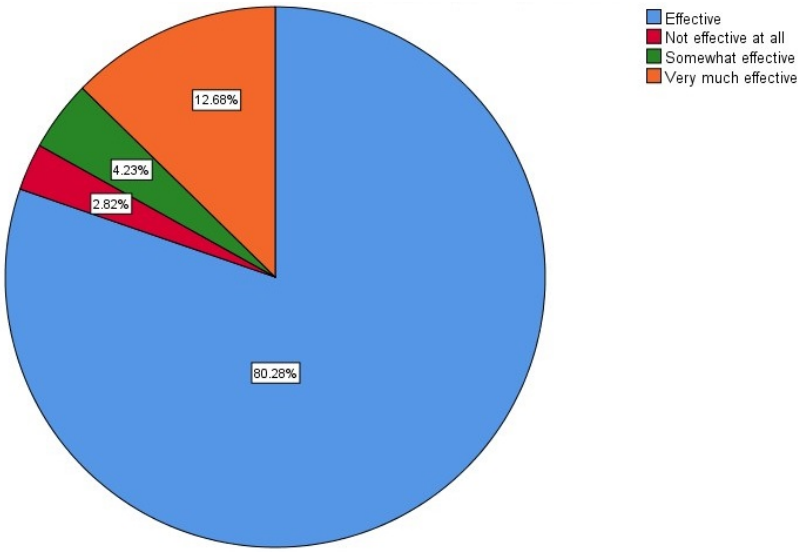

Figure 3.7: Effectiveness of the filters used in the proposed legal dashboard

dashboard displays different types of cases effectively, 3 (4.2%) evaluators shared that the proposed dashboard displays different types of cases ineffectively, 1 (1.4%) evaluators shared that the proposed dashboard displays different types of cases somewhat effectively, whereas 8 (11.3%) evaluators shared that the proposed dashboard displays different types of lawsuits very much effectively.

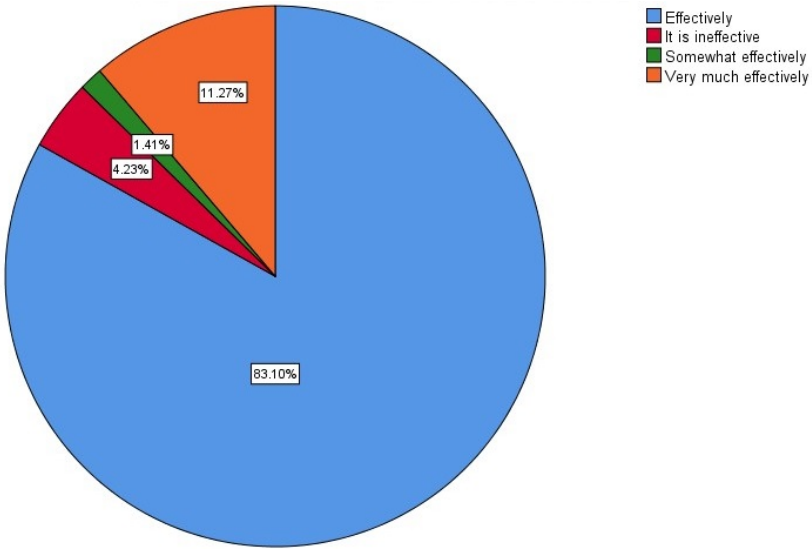

Figure 3.8: Effectiveness of the proposed dashboard to display different lawsuit types

Table 3.8 and figure 3.9 show the opinion of respondents on effectiveness of the proposed dashboard for presenting status of lawsuits.

It can be seen that out of 71 evaluators, 52 (73.2%) evaluators shared that the proposed

Table 3.8: Effectiveness of the proposed dashboard to present status of lawsuits

Effectiveness Level	Frequency	Percent
Effectively	52	73.2
Ineffectively	2	2.8
Somewhat effectively	6	8.5
Very much effectively	11	15.5
Total	71	100.0

dashboard presents the status of cases effectively, 2 (2.8%) evaluators shared that the proposed dashboard presents the status of cases ineffectively, 6 (8.5%) evaluators shared that the proposed dashboard presents the status of cases somewhat effectively, whereas 11 (15.5%) evaluators shared that the proposed dashboard presents the status of cases very much effectively. The majority of the evaluators were of the opinion that the proposed dashboard presents the status of cases effectively.

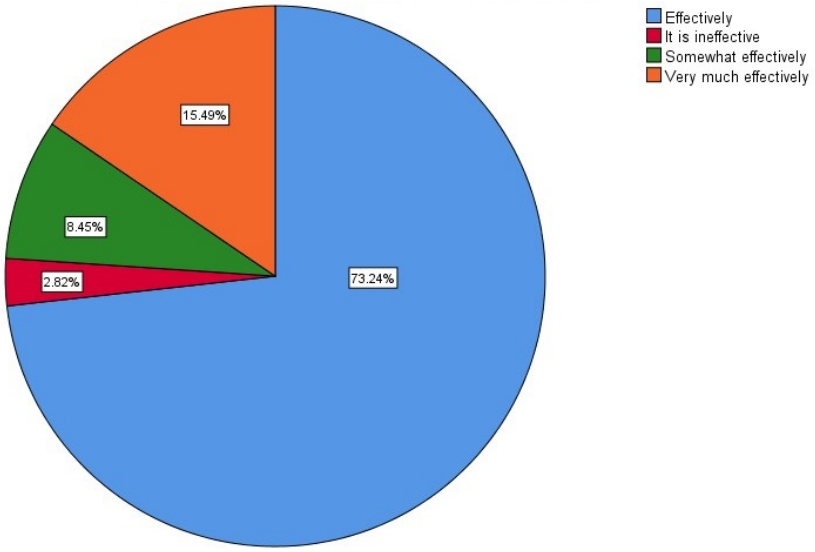

Figure 3.9: Effectiveness of the proposed dashboard to present status of lawsuits

Table 3.9 and figure 3.10 show the opinion of respondents on effectiveness of the dashboard for presenting the implementation duration of court's decision.

It can be seen that out of 71 evaluators, 57 (80.3%) respondents shared that the proposed dashboard presents the implementation duration of court's judgment effectively, 2 (2.8%) evaluators shared that the proposed dashboard presents the implementation duration of court's judgment ineffectively, 4 (5.6%) evaluators shared that the proposed dashboard

Table 3.9: Effectiveness of the dashboard to present decision implementation

Effectiveness Level	Frequency	Percent
Effectively	57	80.3
Ineffectively	2	2.8
Somewhat effectively	4	5.6
Very much effectively	8	11.3
Total	71	100.0

presents the implementation duration of court's judgment somewhat effectively, whereas 8 (11.3%) evaluators shared that the proposed dashboard presents the implementation duration of court's decision very much effectively. The majority of the evaluators were of the opinion that the proposed dashboard presents the implementation duration of court's decision effectively.

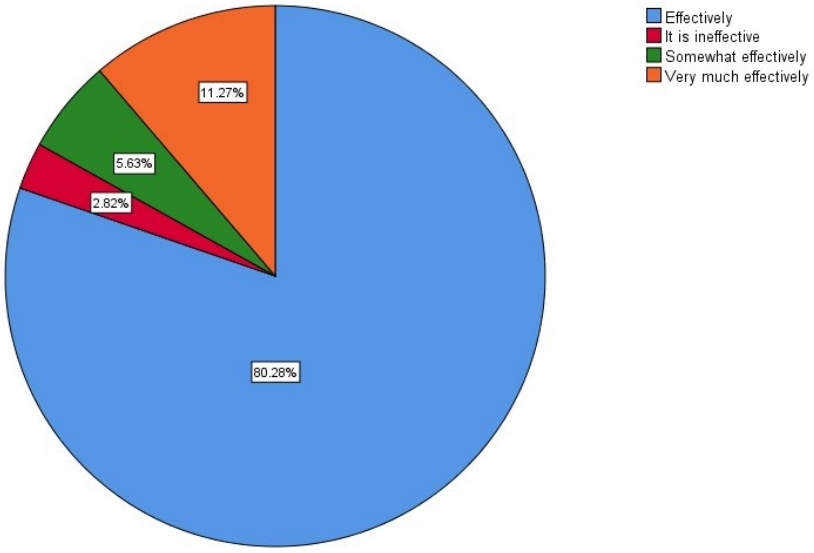

Figure 3.10: Effectiveness of the dashboard to present decision implementation

Table 3.10 and figure 3.11 show the opinion of evaluators on covering legal aspects of the World Justice Project (WJP) in the proposed dashboard.

It can be seen that out of 71 evaluators, 34 (47.9%) evaluators shared that the proposed dashboard covers the legal aspects of the WJP, 1 (1.4%) evaluators shared that the proposed dashboard does not cover the legal aspects of the WJP, 26 (36.6%) evaluators shared that the proposed dashboard somewhat covers the legal aspects of the WJP, whereas 10 (14.1%) evaluators shared that the proposed dashboard very much covers

Table 3.10: Effectiveness of the dashboard to cover legal aspects of the WJP

Coverage Level	Frequency	Percent
Covers legal aspects of the WJP	34	47.9
Does not cover legal aspects of the WJP at all	1	1.4
Somewhat covers legal aspects of the WJP	26	36.6
Very much covers legal aspects of the WJP	10	14.1
Total	71	100.0

the legal aspects of the WJP. The majority of the evaluators were of the opinion that the proposed dashboard covers the legal aspects of the WJP.

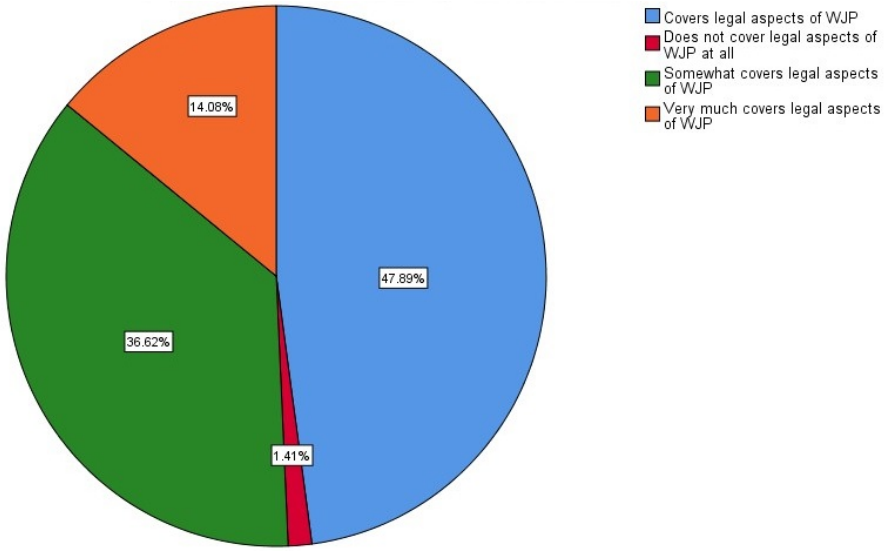

Figure 3.11: Effectiveness of the dashboard to cover legal aspects of the WJP

Table 3.11 and figure 3.12 show the opinion of evaluators on improving the proposed dashboard.

It can be seen that out of 71 evaluators, 8 (11.3%) evaluators shared that the filters and aesthetics of the proposed dashboard need improvement, 18 (25.4%) evaluators shared that the aesthetics of the proposed dashboard need improvement, 31 (43.7%) evaluators shared that the proposed dashboard does not need any improvements, 2 (2.8%) evaluators shared that the filters used in the proposed dashboard need improvement, 4 (5.6%) evaluators shared that the information presented in the dashboard and aesthetics of the proposed dashboard need improvement, whereas 8 (11.3%) evaluators shared that the information presented in the dashboard needs improvement. The majority

Table 3.11: Suggested Improvement in the proposed dashboard

Suggested Improvement	Frequency	Percent
Aesthetics and filters	8	11.3
Aesthetics of the dashboard	18	25.4
Dashboard does not need any improvement	31	43.7
Filters used in the dashboard	2	2.8
Legal information and aesthetics	4	5.6
Legal Information being displayed	8	11.3
Total	71	100.0

of the evaluators were of the opinion that the proposed dashboard does not need any improvements.

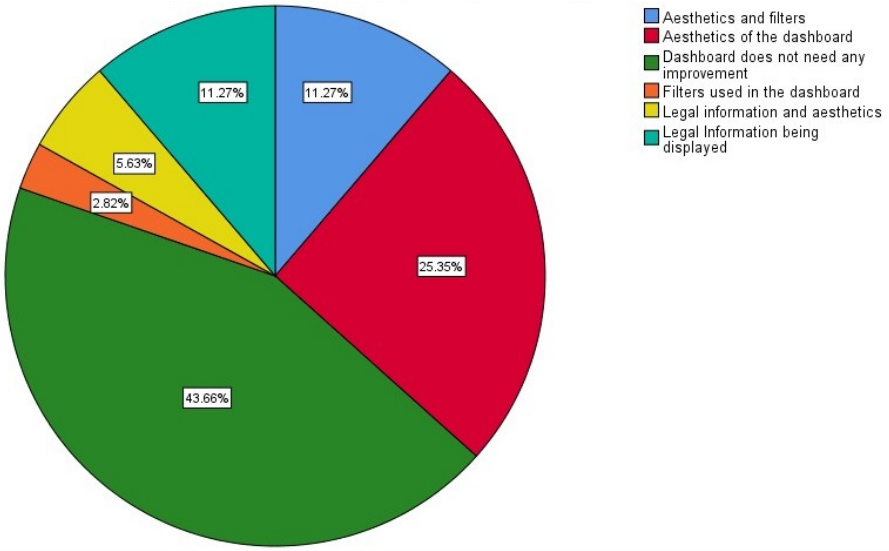

Figure 3.12: Suggested Improvement in the proposed dashboard

Table 3.12 and figure 3.13 show the level of familiarity of the evaluators with legal research websites i.e., PakistanLawSite, indiankanoon, WestLaw, and CaseLaw, etc.

It can be seen that out of 71 evaluators, 21 (29.6%) evaluators shared that they are familiar with legal research websites i.e., PakistanLawSite, indiankanoon, WestLaw, and CaseLaw, etc., 34 (47.9%) evaluators shared that they are somewhat familiar with legal research websites, 10 (14.1%) evaluators shared that they are unfamiliar with legal research websites, whereas 6 (8.5%) evaluators shared that they are very much familiar with legal research websites. The majority of the evaluators were not familiar with legal

Table 3.12: Familiarity level of evaluators with legal research websites

Familiarity Level	Frequency	Percent
Familiar	21	29.6
Somewhat familiar	34	47.9
Unfamiliar	10	14.1
Very much familiar	6	8.5
Total	71	100.0

research websites because the majority of the evaluators were the students of bachelor of law (LLB).

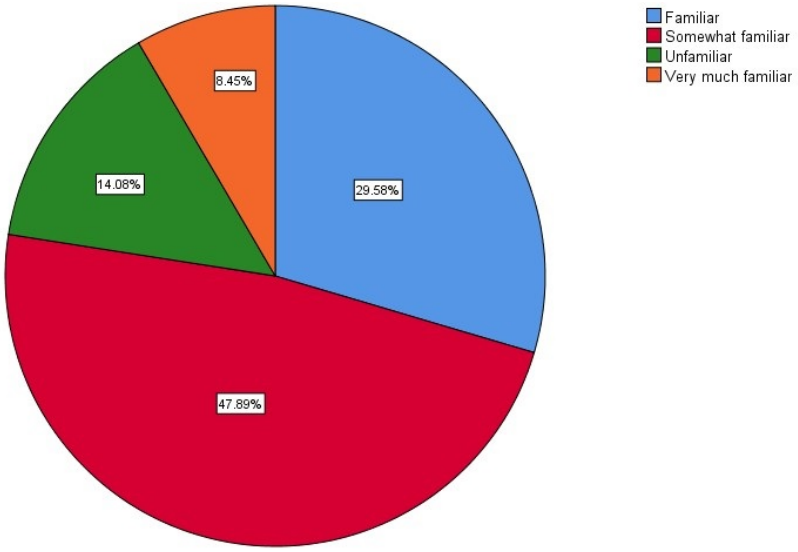

Figure 3.13: Familiarity level of evaluators with legal research websites

Table 3.13 and figure 3.14 show information about the opinion of evaluators on the helpfulness of the legal dashboard to improve the justice system in the country.

Table 3.13: Helpfulness of the legal dashboard to improve justice system

Helpfulness Level	Law Students	Lawyers
Helpful	46	13
Somewhat helpful	4	2
Very much helpful	6	0
Total	56	15

It can be seen that out of 71 evaluators, 56 (78.87%) evaluators were law students.

Out of which, 46 were of the opinion that shared that the proposed dashboard can be useful to improve the justice system, 4 were of the opinion that the proposed dashboard can be somewhat helpful to improve the justice system, and 6 were of the opinion that the proposed dashboard can be very much helpful to improve the justice system in the country. Out of 71 evaluators, 15 (21.13%) evaluators were practicing lawyers. Out of which, 13 were of the opinion that the proposed dashboard can be useful to improve the justice system and 4 were of the opinion that the proposed dashboard can be somewhat helpful to improve the justice system. The majority of the evaluators were of the opinion that the proposed dashboard could be helpful for improving the justice system in the country.

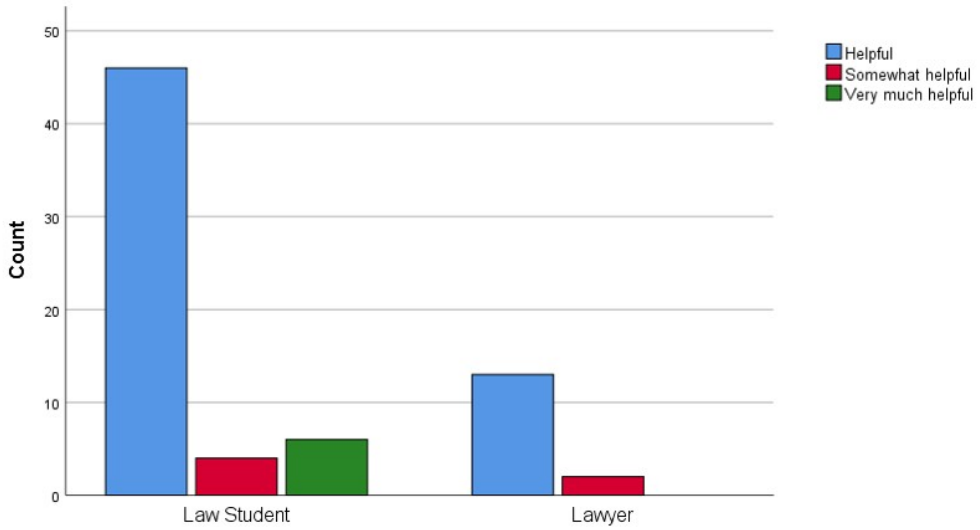

Figure 3.14: Helpfulness of the legal dashboard to improve justice system

It was revealed that the majority of the evaluators were of the opinion that the proposed dashboard would be helpful to improve the performance of Pakistani judiciary.

The case timeline and decision implementation timeline are two significant metrics for the evaluation of the effectiveness of the justice system. The calculation of the case timeline and decision implementation timeline is a difficult task. The upcoming section will discuss these metrics and will present recommendations for the collection of timeline data.

3.4 Recommendations to gather timeline data

The case timeline can be defined as the overall duration of a case in the court. It begins when a case gets registered in any court for the first time and ends when a judgment is made. Whereas the implementation timeline starts when a judgment is made and ends when the implementation of the judgment is done. Following are some recommendations for the acquisition of timeline data:

1. There should be an electronic case management system for all the courts in the country
2. The case management system should be capable of storing case status with the timeline
3. All timelines i.e., case duration and implementation should be stored in a central repository, which can be further connected to the proposed dashboard

3.5 Implementing topic modeling techniques on legal judgments

The proposed solution involves the implementation of three topic modeling techniques i.e., LDA, LSI, and HDP on legal judgments. We used the dataset of 500 judgments of the Supreme Court of Pakistan and Islamabad High Court for the implementation of topic modeling techniques. The implementation was done in python 3.9.4 using Anaconda, Jupyter notebook. Some of the significant libraries used in the implementation include pandas, numpy, nltk, genism, sklearn, pyLDAvis, seaborn, and matplotlib. Figure 3.15 shows the illustration of the proposed solution.

3.5.1 Word Cloud

Word cloud is the image representation of the most frequent words in the corpus, represented by the size of the word. It was created using wordcloud, a python library. It enables us to specify the height, width, and background color of the word cloud. Words with high frequency are appeared to be bigger. Figure 3.16 illustrates the word cloud built on the basis of 10 judgments.

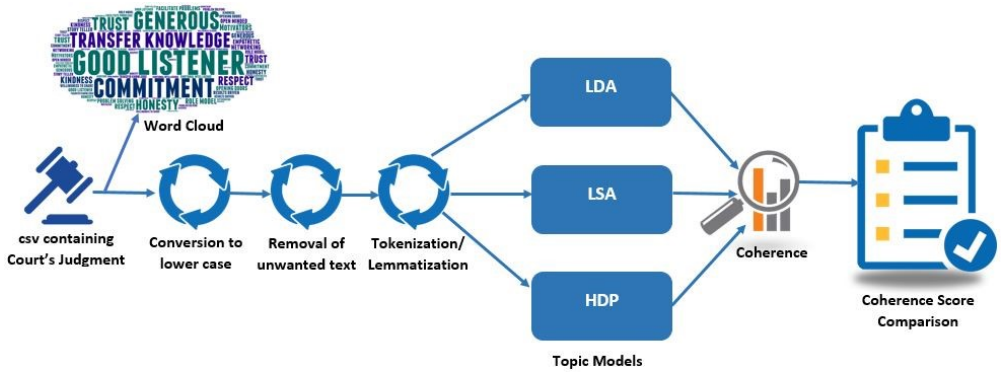

Figure 3.15: Proposed solution (Topic Model Generation)

Figure 3.16: Word Cloud for 10 judgments

It can be seen that respondent, section, appellant, service, workman, authority, case, ordinance, promotion, gratuity, and provident fund are the prominent words in the word cloud, which means that these words are the most frequent words in the corpus of 10 judgments.

Figure 3.17 illustrates the word cloud built on the basis of 100 judgments. It can be seen that respondent, section, appellant, act, case, appeal, rule, ordinance, case, ordinance, fact, law and employee are the prominent words in the word cloud, which means that these words are the most frequent words in the corpus of 100 judgments. Figure 3.18 illustrates the word cloud built on the basis of 500 judgments.

It can be seen that petitioner, respondent, appellant, section, Pakistan, act, appeal,

Figure 3.17: Word Cloud for 100 judgments

rule, council, learned, application, service, order and matter are the prominent words in the word cloud, which means that these words are the most frequent words in the corpus of 500 judgments.

3.5.2 LDA

LDA is an acronym for Latent Dirichlet Allocation, is a popular topic modeling technique. It is a probabilistic model and assumes that the documents in a corpus contain a collection of different topics and the documents are created through a generative process. Figure 3.19 illustrates the HDP topic model.

3.5.3 LSI

LSI is an acronym for Latent Semantic Indexing, also known as Latent Semantic Analysis (LSA). It uses the term co-occurrence for deriving a set of latent concepts, words that repeatedly appear together are assumed to have a strong association. Firstly, it transforms documents into a document term matrix [6]. Then, it approximates source space having lesser dimensions. It uses Singular Value Decomposition (SVD) for achieving decomposition of the original space. It learns latent topics by decomposition of matrix on a term-document matrix. It utilizes SVD to classify patterns in the relationship between terms and the ideas of the content of the document. Document term

Figure 3.18: Word Cloud for 500 judgments

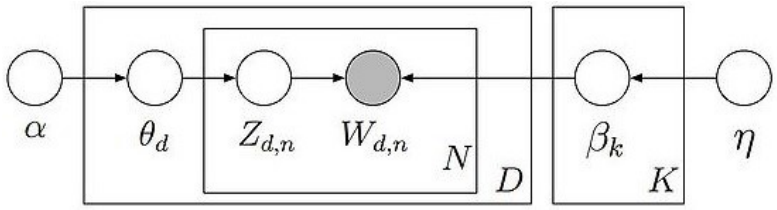

Figure 3.19: LDA Model

matrix X gets decompose into U and V. This decomposition is known as Singular Value Decomposition (SVD).

3.5.4 HDP

HDP is an acronym for Hierarchical Dirichlet Process. It is a nonparametric technique, which is used to model different data groups. Every group is characterized by a mixture model and supports the sharing of mixture components between different groups. This technique presents a hierarchical Bayesian solution that contains a set of Dirichlet processes [31]. The figure 3.20 illustrates the HDP topic model [7].

3.5.5 Results and Discussion

We implemented topic modeling techniques on a corpus of 10, 100, and 500 judgments, which were acquired from the official website of the supreme court of Pakistan and

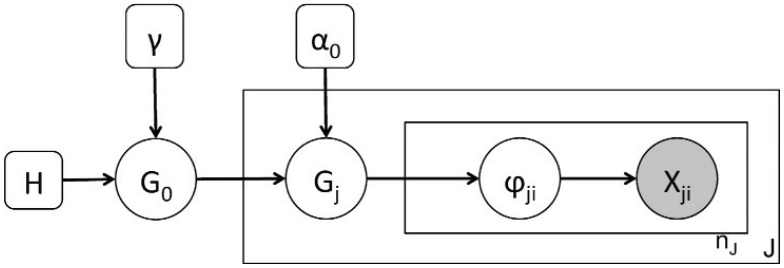

Figure 3.20: HDP Model

Table 3.14: Topics Generated by LDA for 10 judgments

Topic 1		**Topic 2**		**Topic 3**		**Topic 4**	
Word	Score	Word	Score	Word	Score	Word	Score
evidence	.013	promotion	.030	service	.015	respondent	.022
appellant	.013	dpc	.018	also	.012	ordinance	.016
Case	.011	respondent	.017	internet	.011	workman	.015
could	.009	case	.014	pakistan	.010	section	.013
compensation	.007	post	.011	press	.009	authority	.009
learned	.006	service	.009	issued	.008	fund	.008
complainant	.006	consider	.009	application	.008	petitioner	.008
Asc	.005	department	.008	right	.008	law	.007
shop	.005	working	.008	constitution	.008	judgment	.007
muhammad	.005	grant	.008	islamabad	.006	case	.007

Islamabad high court.

Table 3.14 shows results of LDA for 10 judgments. The optimal number of topics for a corpus of 10 judgments was 4. Every topic consists of the top 10 words and the probability associated with them. The higher the probability, the higher the importance of the word in the topic.

The top 10 words in topic 1 include evidence, appellant, case, could, compensation, learned, complainant, asc, shop and muhammad. These words are normal and don't represent any specific type of agenda. The top 10 words in topic 2 include promotion, dpc, respondent, case, post, service, consider, department, working, and grant. The majority of the words such as promotion, post, service, department, and working represent the agenda related to employment. The top 10 words in topic 3 include service, also,

Table 3.15: Topics Generated by LDA for 100 judgments

Topic 1		**Topic 2**		Topic 3		Topic 4		Topic 5		Topic 6	
Word	Score	Word	Score	Word	Score	Word	Score	Word	Score	Word	Score
respondent	.031	respondent	.013	suit	.021	medical	.010	election	.019	section	.016
plot	.021	case	.010	learned	.011	section	.008	respondent	.015	act	.011
membership	.012	learned	.007	order	.010	order	.008	petition	.010	learned	.010
drive	.011	bank	.006	jurisdiction	.010	application	.007	case	.009	case	.007
scheme	.008	order	.006	respondent	.010	dated	.007	section	.008	ordinance	.007
housing	.007	property	.006	judgment	.009	case	.007	order	.007	rule	.007
member	.007	year	.006	agreement	.008	Council	.006	tribunal	.007	respondent	.007
allotment	.006	suit	.005	dated	.007	pw	.006	learned	.007	law	.007
government	.006	appeal	.005	case	.007	respondent	.006	act	.006	order	.006
sugar	.006	dated	.005	civil	.007	pakistan	.006	said	.006	appeal	.006

internet, pakistan, press, issued, application, right, constitution, and islamabad. The majority of the words are meaningless. However, words such as service, application, and right represent the agenda related to employment. The top 10 words in topic 4 include respondent, ordinance, workman, section, authority, fund, petitioner, law, judgment, and case. The majority of the words are meaningless. However, words such as workman and section represent agenda related to employment. In the legal category, the topics tell us that the majority of the judgments are related to employment.

Table 3.15 shows results of LDA for a corpus of 100 judgments. The optimal number of topics for 100 judgments was 6. Every topic consists of the top 10 words and the probability associated with them.

The top 10 words in topic 1 include respondent, plot, membership, drive, scheme, housing, member, allotment, govt, and sugar. The majority of the words such as plot, membership, scheme, housing, and allotment represent the agenda related to the housing scheme. The top 10 words in topic 2 include respondent, case, learned, bank, order, property, year, suit, appeal, and dated. The majority of the words don't represent any specific agenda. The top 10 words in topic 3 include suit, learned, order, jurisdiction, respondent, judgment, agreement, dated, case, and civil. The majority of the words don't represent any specific agenda. The top 10 words in topic 4 include medical, section, order, application, dated, case, council, pw, respondent, and pakistan. The majority of the words don't represent any specific agenda. The top 10 words in topic 5 include election, respondent, petition, case, section, order, tribunal, learned, act, and said. The words such as election, petition, and tribunal represent the agenda related to the election. The

Table 3.16: Topics Generated by LDA for 500 judgments

Topic 1		**Topic 2**		Topic 3		Topic 4		Topic 5		Topic 6	
Word	Score	Word	Score	Word	Score	Word	Score	Word	Score	Word	Score
respondent	.026	government	.012	case	.012	section	.019	order	.018	petitioner	.015
suit	.018	rule	.012	election	.010	act	.015	respondent	.018	section	.015
property	.012	service	.011	section	.009	tax	.010	learned	.015	respondent	.014
learned	.012	pakistan	.011	accused	.008	case	.010	petitioner	.015	company	.012
said	.009	petitioner	.010	learned	.008	appeal	.009	case	.012	rent	.010
dated	.009	federal	.008	muhammad	.006	order	.009	application	.010	learned	.009
agreement	.009	dated	.008	trial	.006	law	.009	dated	.010	case	.008
petitioner	.008	case	.008	also	.006	ordinance	.008	section	.009	petition	.008
plot	.008	respondent	.007	evidence	.006	provision	.007	said	.009	order	.007
sale	.007	authority	.006	offence	.006	learned	.007	party	.009	ordinance	.007

top 10 words in topic 6 include section, act, learned, case, ordinance, rule, respondent, law, order, and appeal. The majority of the words don't represent any specific agenda.

Table 3.16 shows results of LDA for 500 judgments. The optimal number of topics for 500 judgments is 6. Every topic consists of the top 10 words and the probability associated with them. The higher the probability, the higher the importance of the word in the topic.

The top 10 words in topic 1 include respondent, suit, property, learned, said, dated, agreement, petitioner, plot, and sale. The words such as property, agreement, plot, and sale represent the agenda related to property. The top 10 words in topic 2 include government, rule, service, pakistan, petitioner, federal, dated, case, respondent, and authority. The words such as government, service, federal, and rule represent agenda related to employment. The top 10 words in topic 3 include case, election, section, accused, learned, muhammad, trial, also, evidence, and offence. The majority of the words don't represent any specific agenda. The top 10 words in topic 4 include section, act, tax, case, appeal, order, law, ordinance, provision, and learned. The majority of the words don't represent any specific agenda. The top 10 words in topic 5 include order, respondent, learned, petitioner, case, application, dated, section, said, and party. The majority of the words don't represent any specific agenda. The top 10 words in topic 6 include petitioner, section, respondent, company, rent, learned, case, petition, order, and ordinance. The words such as company and rent represent the agenda related to tenancy.

The optimal number of topics for LSA is 4. Table 3.17 shows 4 topics generated by LSA.

Table 3.17: Topics Generated by LSA Model for 10 judgments

Topic 1		**Topic 2**		**Topic 3**		**Topic 4**	
Word	Score	Word	Score	Word	Score	Word	Score
respondent	-.421	evidence	-.383	government	-.227	promotion	-.470
workman	-.348	appellant	-.374	promotion	-.226	dpc	-.288
ordinance	-.269	case	-.188	also	-.216	respondent	-.208
section	-.195	complainant	-.178	press	-.190	post	-.168
petitioner	-.176	could	-.159	pakistan	-.182	pakistan	.159
authority	-.175	shop	-.142	workman	.166	press	.150
fund	-.168	confession	-.131	constitution	-.166	service	-.146
case	-.165	muhammad	-.129	issued	-.166	also	.145
service	-.158	workman	.124	evidence	.160	consider	-.135
provident	-.150	thus	-.107	right	-.154	case	-.123

Every topic consists of the top 10 words and the probability associated with them. The higher the probability, the higher the importance of the word in the topic.

The top 10 words in topic 1 include respondent, workman, ordinance, section, petitioner, authority, fund, case, service, and provident. The words such as workman, section, service, and provident represent the agenda of employment. The top 10 words in topic 2 include evidence, appellant, case, complainant, could, shop, confession, Muhammad, workman, and thus. The majority of the words don't represent any specific agenda. However, the word "workman" represents the agenda related to employment. The top 10 words in topic 3 include government, promotion, also, press, Pakistan, workman, constitution, issued, evidence, and right. The words such as promotion and workman represent the agenda related to employment. The top 10 words in topic 4 include promotion, dpc, respondent, post, Pakistan, press, service, also, consider, and case. The majority of the words don't represent any specific agenda. However, words such as promotion, dpc, post, and service represent the agenda related to employment. It is evident that the majority of the judgments in the corpus are related to employment.

The optimal number of topics for 100 judgments in LSA is 6. Table 3.18 shows 6 topics generated by LSA. Every topic consists of the top 10 words and the probability associated with them.

Table 3.18: Topics Generated by LSA for 100 judgments

Topic 1		**Topic 2**		Topic 3		Topic 4		Topic 5		Topic 6	
Word	Score	Word	Score	Word	Score	Word	Score	Word	Score	Word	Score
suit	.010	government	.006	service	.012	election	.009	regulation	.011	order	.007
respondent	.009	section	.006	act	.011	respondent	.008	section	.010	learned	.007
case	.008	sugar	.006	company	.011	case	.006	ordinance	.008	rule	.006
learned	.008	act	.006	section	.010	learned	.005	act	.008	respondent	.006
appeal	.007	board	.004	heading	.008	tribunal	.005	rule	.008	jurisdiction	.006
order	.007	shall	.004	pct	.007	service	.004	appeal	.007	section	.005
high	.006	case	.004	excise	.007	petition	.004	bank	.006	suit	.005
property	.005	rule	.004	federal	.006	section	.004	government	.006	judgment	.005
said	.005	order	.004	learned	.005	order	.004	law	.005	islamabad	.004
tax	.005	sro	.004	tax	.004	also	.004	statutory	.005	london	.004

The top 10 words in topic 1 include suit, respondent, case, learned, appeal, order, high, property, said, and tax. The majority of the words don't represent any specific agenda. The top 10 words in topic 2 include government, section, sugar, act, board, shall, case, rule, order, and sro. The majority of the words don't represent any specific agenda. The top 10 words in topic 3 include service, act, company, section, heading, pct, excise, federal, learned, and tax. The words such as excise, federal, and tax represent taxation related agenda. The top 10 words in topic 4 include election, respondent, case, learned, tribunal, service, petition, section, order, and also. The majority of the words don't represent any specific agenda. The top 10 words in topic 5 include regulation, section, ordinance, act, rule, appeal, bank, government, law, and statutory. The majority of the words don't represent any specific agenda. The top 10 words in topic 6 include order, learned, rule, respondent, jurisdiction, section, suit, judgment, islamabad, and london. The majority of the words don't represent any specific agenda.

The optimal number of topics for 500 judgments in LSA is 6. Table 3.19 shows 6 topics generated by LSA. Every topic consists of the top 10 words and the probability associated with them.

The top 10 words in topic 1 include respondent, petitioner, learned, case, section, order, dated, said, act, and suit. The majority of the words don't represent any specific agenda. The top 10 words in topic 2 include respondent, section, suit, petitioner, act, agreement, government, service, rule, and pakistan. The majority of the words don't represent any specific agenda. The top 10 words in topic 3 include petitioner, suit, service, petition, property, pw, muhammad, employee, evidence, and section. The majority of the words

Table 3.19: Topics Generated by LSA for 500 judgments

Topic 1		**Topic 2**		Topic 3		Topic 4		Topic 5		Topic 6	
Word	Score	Word	Score	Word	Score	Word	Score	Word	Score	Word	Score
respondent	-.336	respondent	-.439	petitioner	-.588	respondent	.393	section	.333	respondent	.428
petitioner	-.254	section	.300	suit	.229	petitioner	-.393	order	.298	suit	-.331
learned	-.241	suit	-.282	service	-.184	case	-.194	service	-.226	rule	-.267
case	-.229	petitioner	-.261	petition	-.184	act	.190	respondent	-.221	section	.222
section	-.229	act	.218	property	.173	muhammad	-.158	rule	-.193	order	-.210
order	-.214	agreement	-.186	pw	.132	pw	-.155	government	-.178	civil	-.192
dated	-.175	government	.145	muhammad	.121	accused	-.152	application	.166	company	.1555
said	-.173	service	.145	employee	-.117	agreement	.150	rent	.164	dated	-.143
act	-.162	rule	.141	evidence	.116	trial	-.127	act	.163	learned	-.138
suit	-.134	pakistan	.129	section	.111	arbitration	.123	pw	-.129	decree	-.125

don't represent any specific agenda. The top 10 words in topic 4 include respondent, petitioner, case, act, muhammad, pw, accused, agreement, trial, and arbitration. The majority of the words don't represent any specific agenda. The top 10 words in topic 5 include section, order, service, respondent, rule, government, application, rent, act, and pw. The majority of the words don't represent any specific agenda. The top 10 words in topic 6 include respondent, suit, rule, section, order, civil, company, dated, learned, and decree. The majority of the words don't represent any specific agenda.

The optimal number of topics for 10 judgments in HDP is 4. Table 3.20 shows 6 topics generated by HDP. Every topic consists of the top 10 words and the probability associated with them.

The top 10 words in topic 1 include respondent, workman, ordinance, petitioner, authority, fund, section, provident, gratuity, and service. The words such as workman, section, provident, gratuity, and service represent the agenda related to employment. The top 10 words in topic 2 include evidence, appellant, complainant, case, could, shop, confession, Muhammad, witness, and thus. These words are normal and don't represent any specific type of agenda. The top 10 words in topic 3 include service, section, judgment, internet, act, ordinance, respondent, decree, and property. The majority of the words don't represent any specific agenda. However, words such as service and section represents the agenda related to employment. The top 10 words in topic 4 include government, Sindh, land, commissioner, also, Karachi, shall, deputy, Jacobabad, and plot. The word such as Jacobabad, Karachi, Sindh, land, plot, commissioner, government represent agenda related to land involving the Sindh government. The two main types

Table 3.20: Topics Generated by HDP for 10 judgments

Topic 1		**Topic 2**		**Topic 3**		**Topic 4**	
Word	Score	Word	Score	Word	Score	Word	Score
respondent	.028	evidence	.019	service	.018	government	.015
workman	.026	appellant	.018	section	.016	sindh	.013
ordinance	.018	complainant	.009	judgment	.013	land	.012
petitioner	.013	case	.009	internet	.013	commissioner	.012
authority	.013	could	.008	act	.013	also	.009
fund	.012	shop	.007	banking	.012	karachi	.009
section	.012	confession	.007	ordinance	.011	shall	.008
provident	.011	muhammad	.007	respondent	.010	deputy	.007
gratuity	.011	witness	.005	decree	.010	jacobabad	.006
service	.010	thus	.005	property	.010	plot	.006

of judgments identified by the HDP model in the corpus of judgments include judgments related to employment and judgment on land acquisition.

The optimal number of topics for 100 judgments in HDP is 6. Table 3.21 shows 6 topics generated by HDP. Every topic consists of the top 10 words and the probability associated with them.

The top 10 words in topic 1 include section, ordinance, act, rule, regulation, government, learned, shall, statutory, and engineer. The majority of the words don't represent any

Table 3.21: Topics Generated by HDP for 100 judgments

Topic 1		**Topic 2**		Topic 3		Topic 4		Topic 5		Topic 6	
Word	Score	Word	Score	Word	Score	Word	Score	Word	Score	Word	Score
section	.010	election	.007	company	.012	respondent	.018	defence	.014	year	.006
ordinance	.009	tribunal	.007	section	.008	medical	.014	division	.006	respondent	.006
act	.008	section	.006	act	.006	plot	.011	respondent	.005	petitioner	.006
rule	.007	order	.006	learned	.006	membership	.010	department	.004	age	.005
regulation	.007	learned	.006	case	.005	drive	.009	pakistan	.004	also	.005
government	.006	appeal	.006	person	.004	council	.009	paid	.004	case	.005
learned	.006	dated	.005	respondent	.004	member	.008	appeal	.004	learned	.005
shall	.006	case	.005	may	.004	scheme	.007	employee	.004	dated	.004
statutory	.005	rule	.005	petition	.004	government	.006	dated	.004	child	.004
engineer	.005	said	.004	law	.004	pakistan	.006	attached	.004	section	.003

Table 3.22: Topics Generated by HDP for 500 judgments

Topic 1		**Topic 2**		Topic 3		Topic 4		Topic 5		Topic 6	
Word	Score	Word	Score	Word	Score	Word	Score	Word	Score	Word	Score
respondent	.013	respondent	.016	respondent	.009	case	.010	case	.009	respondent	.009
petitioner	.012	petitioner	.012	learned	.007	petitioner	.010	section	.008	case	.007
learned	.010	learned	.011	case	.006	section	.006	learned	.007	learned	.007
case	.010	case	.009	dated	.006	dated	.006	petitioner	.006	section	.007
order	.010	section	.009	service	.006	respondent	.006	dated	.006	petitioner	.005
section	.009	order	.009	said	.005	order	.005	said	.006	statement	.005
dated	.007	dated	.007	section	.005	learned	.005	shall	.005	order	.004
said	.007	said	.007	act	.005	petition	.005	order	.005	law	.004
act	.006	suit	.007	petitioner	.005	said	.005	pakistan	.005	pw	.004
suit	.006	act	.006	rule	.005	counsel	.004	respondent	.004	also	.004

specific agenda. The top 10 words in topic 2 include election, tribunal, section, order, learned, appeal, dated, case, rule, and said. The majority of the words don't represent any specific agenda. The top 10 words in topic 3 include company, section, act, learned, case, person, respondent, may, petition, and law. The majority of the words don't represent any specific agenda. The top 10 words in topic 4 include respondent, medical, plot, membership, drive, council, member, scheme, government, and pakistan. The words such as plot, membership, scheme, and member represent housing scheme related agenda. The top 10 words in topic 5 include defence, division, respondent, department, pakistan, paid, appeal, employee, dated, and attached. The words such as defence, division, department, paid, and employee represent an employment related agenda. The top 10 words in topic 6 include year, respondent, petitioner, age, also, case, learned, dated, child, and section. The majority of the words don't represent any specific agenda.

The optimal number of topics for 500 judgments in HDP is 6. Table 3.22 shows 6 topics generated by HDP. Every topic consists of the top 10 words and the probability associated with them.

The top 10 words in topic 1 include respondent, petitioner, learned, case, order, section, dated, said, act, and suit. The majority of the words don't represent any specific agenda. The top 10 words in topic 2 include respondent, petitioner, learned, case, section, order, dated, said, suit, and act. The majority of the words don't represent any specific agenda. The top 10 words in topic 3 include respondent, learned, case, dated, service, said, section, act, petitioner, and rule. The majority of the words don't represent any specific agenda. The top 10 words in topic 4 include case, petitioner, section, dated, respondent,

order, learned, petition, said, and counsel. The majority of the words don't represent any specific agenda. The top 10 words in topic 5 include case, section, learned, petitioner, dated, said, shall, order, pakistan, and respondent. The majority of the words don't represent any specific agenda. The top 10 words in topic 6 include respondent, case, learned, section, petitioner, statement, order, law, pw, and also. The majority of the words don't represent any specific agenda.

It can be observed that as the number of judgment increases, the ability of all of the three topic modeling techniques degrades.

Figure 3.19 illustrates the topic created by the LDA model using Gensim library.

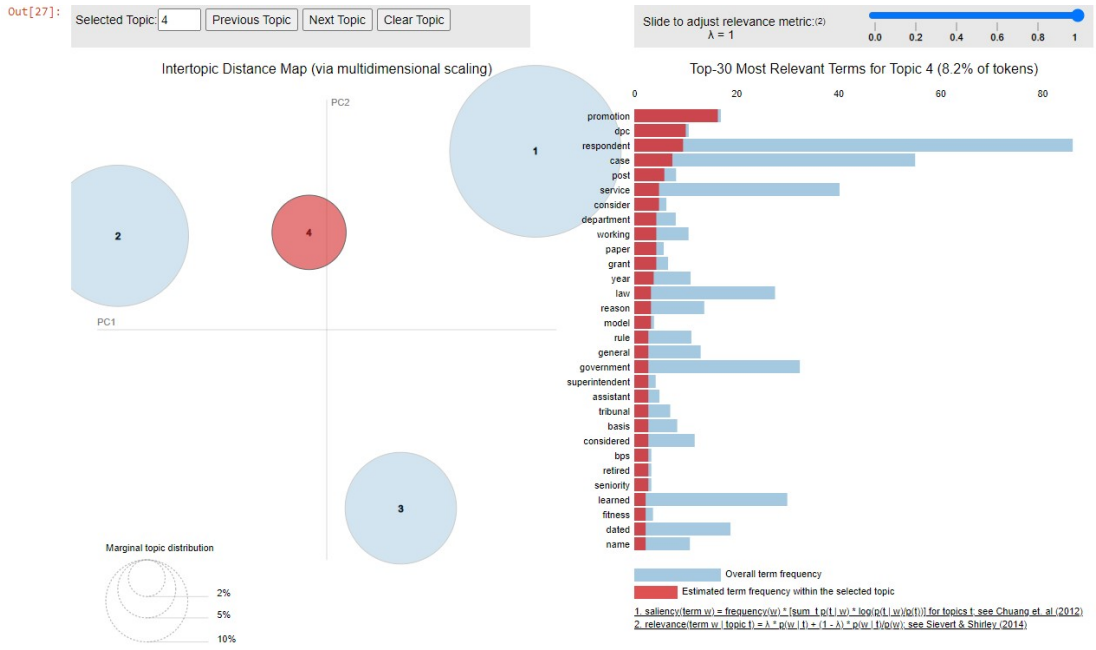

Figure 3.21: Topics Created by LDA Model using Gensim

Four circles on the left-hand side of figure 19 represent 4 topics. Topic 4, displayed in red colour is the selected topic. Bars on the right-hand side of the figure represent the top 30 words and their frequencies. The blue bar represents the overall frequency of the word in the corpus whereas the red bar represents the frequency of the word in the selected topic. It can be seen that there are some words in the topic that don't represent any specific agenda. However, words such as promotion, dpc, post, service, superintendent, assistant, and bps represent employment related topic.

3.6 Evaluating Topic Models

Topic modeling is an unsupervised machine learning technique. The selection of an appropriate topic modeling technique for implementation is a tricky task. There are certain measures that are used to evaluate the ability of the topic modeling techniques to summarize the thematic structure of each document in the corpus [1]. This study will be using coherence to evaluate the performance of the topic modeling techniques.

3.6.1 Coherence

Coherence is a popular topic model evaluation metric. It is used to measure semantic similarity between words having a high score in a topic. It helps differentiate between semantically differentiable topics and other topics. There exist four types of coherence metrics i.e., C_v, C_umass, C_uci, and C_npmi. In this study, we used C_v to evaluate topic models. C_v evaluates topic models on the basis of a sliding window, a one-set segmentation of the top words, and an indirect confirmation measure [30]. It has been found an appropriate metric to evaluate the quality of topics on the basis of a large-scale empirical comparison with other topic coherence measures and yields scores near to human evaluation.

Figure 3.22 shows the coherence score of LDA, LSA, and HDP topic models for a corpus of 10 judgments.

It can be seen that the coherence score achieved by the LDA model was .4583. The coherence score achieved by the LSA model was .4425, and the coherence score achieved by the HDP model was .7263. The HDP model outperformed the LDA and LSA models.

Figure 3.23 shows the coherence score of LDA, LSA, and HDP topic models for a corpus of 100 judgments.

It can be seen that the coherence score achieved by the LDA model was .3455. The coherence score achieved by the LSA model was .4499, and the coherence score achieved by the HDP model was .6599. The HDP model outperformed the LDA and LSA models.

Figure 3.24 shows the coherence score of LDA, LSA, and HDP topic models for a corpus of 500 judgments.

It can be seen that the coherence score achieved by the LDA model was .4054. The

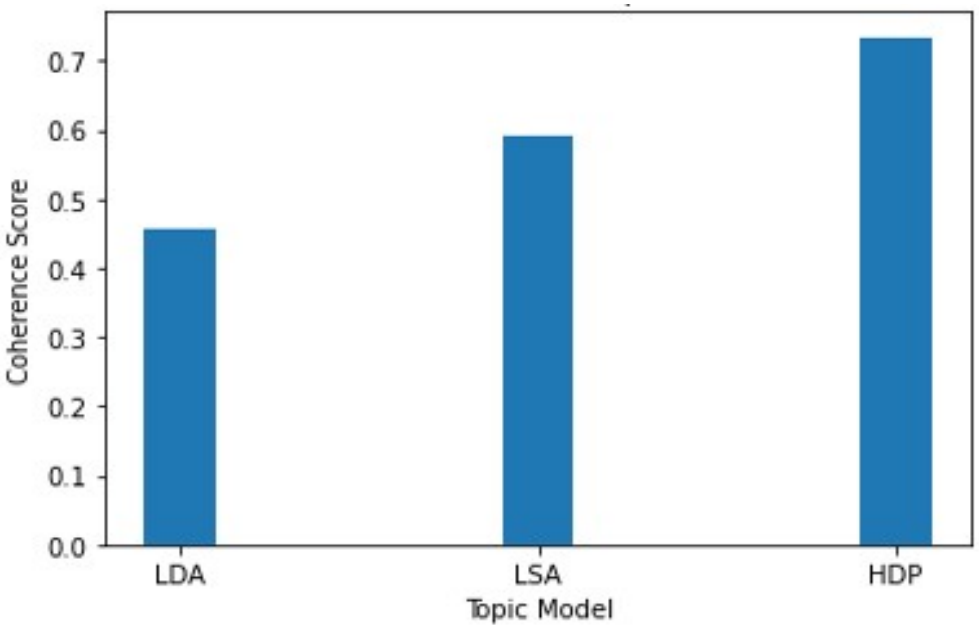

Figure 3.22: Coherence Score of LDA, LSA, and HDP for 10 judgments

coherence score achieved by the LSA model was .3905, and the coherence score achieved by the HDP model was .5363. It can be observed that for a corpus of 10 and 100 judgments, LSA performed better than LSA, but for a corpus of 500 judgments, LDA performed better than LSA. However, the HDP model outperformed the LDA and LSA.

3.7 Tools

Following tools were used for implementation and evaluation of the proposed solution:

- MS Power BI (Desktop)
- IBM SPSS Version 26
- Jupyter Notebook

Chapter 4 will discuss conclusion, future direction, and limitations of this study.

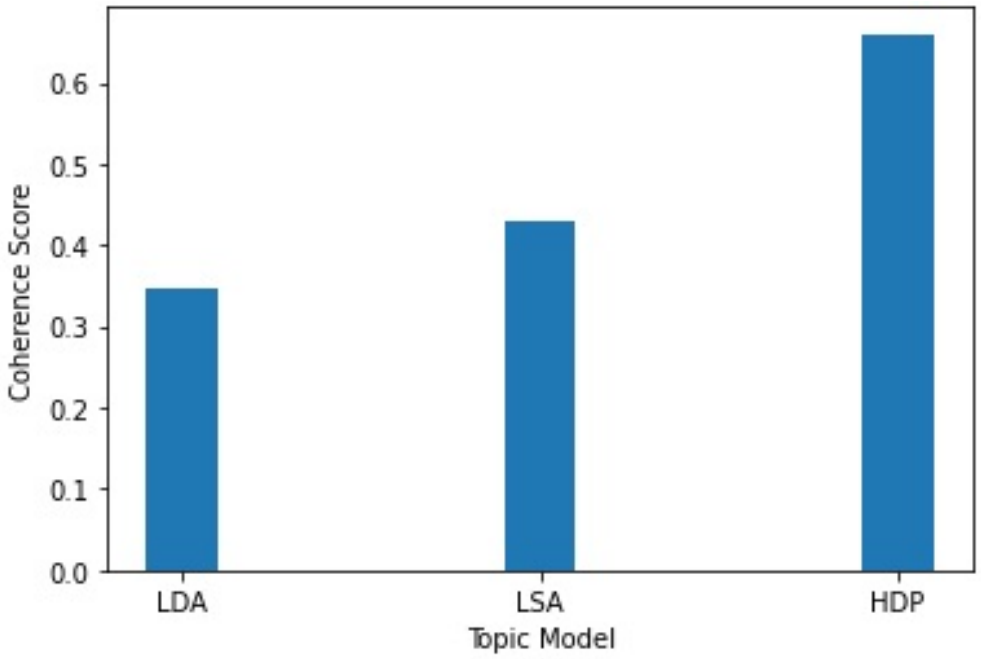

Figure 3.23: Coherence Score of LDA, LSA, and HDP for 100 judgments

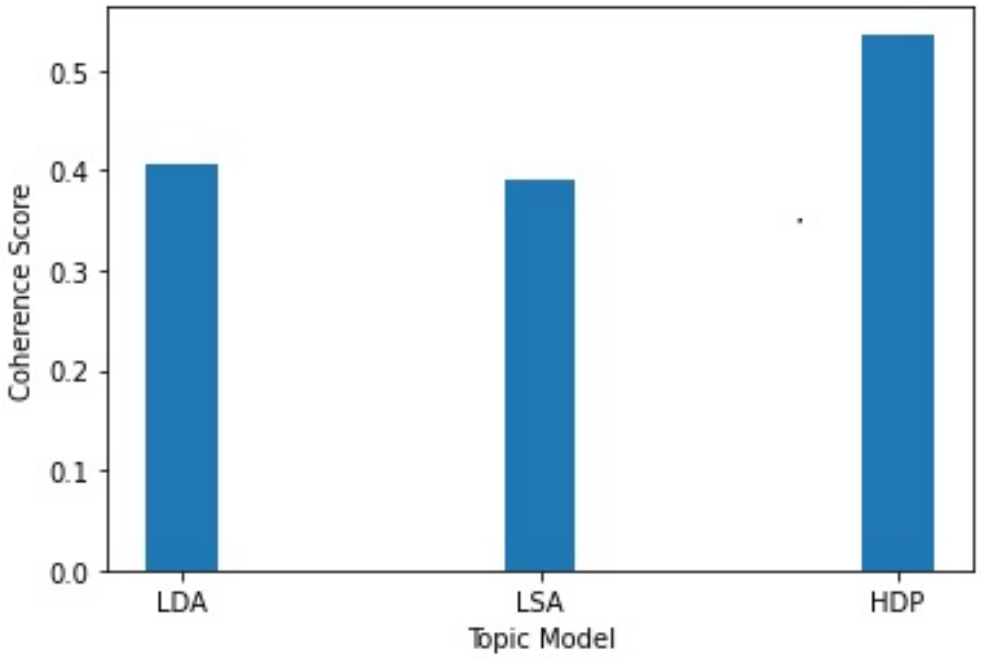

Figure 3.24: Coherence Score of LDA, LSA, and HDP for 500 judgments

Chapter 4

Conclusion, Future Direction, and limitations

4.1 Conclusion

In this thesis, we proposed an analytics-based solution to improve the performance of the judicial system in Pakistan. This can help to improve the rank of Pakistan in the World Justice Project (WJP). The WJP uses different factors to calculate the rank of a country, out of which an effective justice system is a significant factor. The proposed solution is a legal dashboard that provides information about various lawsuits registered with the Supreme court of Pakistan and its sub-courts. Since the implementation of Information Technology has not yet been mature enough in the legal sector of the country and currently, the Pakistani judiciary is in the process of transforming all its records into electronic form, that's why the significant amount of dataset was unavailable. Hence, we scraped data of judgments from the official websites of the Supreme Court of Pakistan and its sub-courts. Some of the data such as the names of courts, judges, date of lawsuit registration, and type of case was used from scraped data while we used dummy data for unavailable information such as pending cases, case duration, and judgment implementation duration. The proposed solution was evaluated by legal practitioners and law students of renowned law schools in Islamabad. The majority of the evaluators were of the opinion that:

- The information shown in the legal dashboard and different components of the proposed dashboard are effective

- The proposed solution will help the higher management of the judiciary to monitor the performance of various courts with respect to the judges, case type, timeline of the resolved and pending cases, and the timeline of decision implementation
- The judicial management will be able to identify weak areas and devise strategies for improvement
- The proposed solution has the potential to improve the effectiveness of the justice system in Pakistan

Past judgments play an important role in resolving current cases, as they are used as a reference. Keeping this in view, legal practitioners spend a significant amount of time reading past judgments, which requires time and energy. The majority of the time, after reading a document it comes to know that the judgment was not of interest. There was a lack of a system that can help legal practitioners to find whether judgment(s) is of their interest or not. In this context, we introduced a solution that provides insights into legal judgments. In this study, we implemented three topic modeling techniques i.e., LDA, LSA, and HDP using 500 judgments scraped from the website of the Supreme Court of Pakistan and Islamabad high court. Implementation was done in Python language using Jupyter Notebook. The performance of the topic modeling techniques was evaluated using the coherence CV. The topic modeling techniques were implemented using 10, 100, and 500 judgments. The HDP model outperformed all other topic modeling techniques and was found to be the best topic modeling technique for judgments. However, it was observed that when the number of judgments increases, the coherence score decreases.

4.2 Future Direction

In the future, we aim to include advanced analytics and machine learning techniques in our study. This will help the judiciary to have a visualization-based prediction of the lawsuits of their interest with respect to judges, courts, and timeframe. Apart from that, we shall explore the topic modeling techniques that yield good results on more than 500 judgments.

4.3 Limitations

The implementation of IT in various sectors in Pakistan is not yet mature enough. The Pakistani judiciary is in the process of automating the judicial system. Currently, they are transforming their lawsuit data into electronic form but due to the large volume of records, it will take time. Due to the unavailability of lawsuit data, we scraped past judgments from the official website of the Supreme Court of Pakistan and Islamabad high court and used them in our study. We used dummy data for the information that was unavailable. The unavailability of lawsuit data was the main limitation of this study. Apart from that, the results indicate that the performance of the topic modeling techniques degrades as we increase the number of judgments.

Bibliography

[1] Keith Stevens et al. “Exploring topic coherence over many models and many topics”. In: *Proceedings of the 2012 joint conference on empirical methods in natural language processing and computational natural language learning*. 2012, pp. 952–961.

[2] Ozlem Oktal et al. “Trust in adoption to judiciary informatics system of senior management users”. In: *Third International Conference on Innovative Computing Technology (INTECH 2013)*. IEEE. 2013, pp. 92–96.

[3] Amn Rahman et al. “Finding needle in the case-stack: effective remote monitoring of courts”. In: *2014 47th Hawaii International Conference on System Sciences*. IEEE. 2014, pp. 1906–1915.

[4] Jocelyn Mazarura and Alta De Waal. “A comparison of the performance of latent Dirichlet allocation and the Dirichlet multinomial mixture model on short text”. In: *2016 Pattern Recognition Association of South Africa and Robotics and Mechatronics International Conference (PRASA-RobMech)*. IEEE. 2016, pp. 1–6.

[5] Luis Raúl Rodrıguez Oconitrillo and Alvaro de la Ossa Osegueda. “Business intelligence model to support a judge’s decision making about legal situations”. In: *2016 IEEE 36th Central American and Panama Convention (CONCAPAN XXXVI)*. IEEE. 2016, pp. 1–5.

[6] Bhagyashree Vyankatrao Barde and Anant Madhavrao Bainwad. “An overview of topic modeling methods and tools”. In: *2017 International Conference on Intelligent Computing and Control Systems (ICICCS)*. IEEE. 2017, pp. 745–750.

[7] Joan Capdevila et al. “Tweet-SCAN: An event discovery technique for geo-located tweets”. In: *Pattern Recognition Letters* 93 (2017), pp. 58–68.

[8] Ambedkar Kanapala, Sukomal Pal, and Rajendra Pamula. "Design of a meta search system for legal domain". In: *2017 4th International Conference on Advanced Computing and Communication Systems (ICACCS)*. IEEE. 2017, pp. 1–5.

[9] Alexey P Shiryaev et al. "LDA models for finding trends in technical knowledge domain". In: *2017 IEEE Conference of Russian Young Researchers in Electrical and Electronic Engineering (EIConRus)*. IEEE. 2017, pp. 551–554.

[10] J Sluijter and M Otten. "Business intelligence (BI) for personalized student dashboards". In: *Proceedings of the seventh international learning analytics & knowledge conference*. 2017, pp. 562–563.

[11] CV Sneha et al. "Comprehensive analysis of CSR data using interactive reports". In: *2017 International Conference on Energy, Communication, Data Analytics and Soft Computing (ICECDS)*. IEEE. 2017, pp. 1460–1463.

[12] Wenxing Hong et al. "Project Rank: An internet topic evaluation model based on latent dirichlet allocation". In: *2018 13th International Conference on Computer Science & Education (ICCSE)*. IEEE. 2018, pp. 1–4.

[13] Wasinee Noonpakdee et al. "A framework for analyzing and developing dashboard templates for small and medium enterprises". In: *2018 5th International Conference on Industrial Engineering and Applications (ICIEA)*. IEEE. 2018, pp. 479–483.

[14] Ritika Pandey and George O Mohler. "Evaluation of crime topic models: topic coherence vs spatial crime concentration". In: *2018 IEEE International Conference on Intelligence and Security Informatics (ISI)*. IEEE. 2018, pp. 76–78.

[15] Anwar Ur Rehman et al. "Statistical topic modeling for Urdu text articles". In: *2018 24th International Conference on Automation and Computing (ICAC)*. IEEE. 2018, pp. 1–6.

[16] Md Hasan et al. "Topic modelling: A comparison of the performance of latent Dirichlet allocation and LDA2vec model on Bangla newspaper". In: *Proc. Int. Conf. Bangla Speech Lang. Process.(ICBSLP)*. 2019, pp. 1–5.

[17] Robert Keeling et al. "Empirical comparisons of CNN with other learning algorithms for text classification in legal document review". In: *2019 IEEE International Conference on Big Data (Big Data)*. IEEE. 2019, pp. 2038–2042.

[18] Zhonghao Li. "A classification retrieval approach for English legal texts". In: *2019 International Conference on Intelligent Transportation, Big Data & Smart City (ICITBS)*. IEEE. 2019, pp. 220–223.

[19] Syed Rameel Ahmad, Deborah Harris, and Ibrahim Sahibzada. "Understanding legal documents: classification of rhetorical role of sentences using deep learning and natural language processing". In: *2020 IEEE 14th International Conference on Semantic Computing (ICSC)*. IEEE. 2020, pp. 464–467.

[20] Mohammed Ameer, Simhadri Prem Rahul, and Suneetha Manne. "Human Resource Analytics using Power Bi Visualization Tool". In: *2020 4th International Conference on Intelligent Computing and Control Systems (ICICCS)*. IEEE. 2020, pp. 1184–1189.

[21] Nishant Jain and Gaurav Goel. "An Approach to Get Legal Assistance Using Artificial Intelligence". In: *2020 8th International Conference on Reliability, Infocom Technologies and Optimization (Trends and Future Directions) (ICRITO)*. 2020, pp. 768–771. DOI: 10.1109/ICRITO48877.2020.9198029.

[22] Tereza Novotná, Jakub Harašta, and Jakub Kól. "Topic Modelling of the Czech Supreme Court Decisions". In: (2020).

[23] Ryszard Pukala et al. "Power BI in ICT for Monitoring of Insurance Activity Based on Indicators of Insurance Portfolios". In: *2020 IEEE International Conference on Problems of Infocommunications. Science and Technology (PIC S&T)*. IEEE. 2020, pp. 393–401.

[24] Nuutthapachr Sethasathien and Patipan Prasertsom. "Research Topic Modeling: A Use Case for Data Analytics on Research Project Data". In: *2020 1st International Conference on Big Data Analytics and Practices (IBDAP)*. IEEE. 2020, pp. 1–6.

[25] Stefanie Urchs, Jelena Mitrović, and Michael Granitzer. "Towards Classifying Parts of German Legal Writing Styles in German Legal Judgments". In: *2020 10th International Conference on Advanced Computer Information Technologies (ACIT)*. IEEE. 2020, pp. 451–454.

[26] Bruno Varela, Jorge Bernardino, and Isabel Pedrosa. "Twitter sensitivity analysis in a higher school using power BI". In: *2020 15th Iberian Conference on Information Systems and Technologies (CISTI)*. IEEE. 2020, pp. 1–6.

[27] Caradee Y Wright and Bianca Wernecke. "Using Microsoft© Power BI© to visualise Rustenburg Local Municipality's Air Quality Data". In: *Clean Air Journal* 30.1 (2020), pp. 1–5.

[28] Ravi Helon MS Ferreira et al. "IIoT Solution for predictive monitoring based on vibration data from motors using Microsoft Azure machine learning studio and Power BI". In: *2021 14th IEEE International Conference on Industry Applications (INDUSCON)*. IEEE. 2021, pp. 145–152.

[29] Deepali Jain, Malaya Dutta Borah, and Anupam Biswas. "Automatic Summarization of Legal Bills: A Comparative Analysis of Classical Extractive Approaches". In: *2021 International Conference on Computing, Communication, and Intelligent Systems (ICCCIS)*. IEEE. 2021, pp. 394–400.

[30] Seemab Latif, Faisal Shafait, Rabia Latif, et al. "Analyzing LDA and NMF Topic Models for Urdu Tweets via Automatic Labeling". In: *IEEE Access* 9 (2021), pp. 127531–127547.

[31] George Manias et al. "Real-Time Kafka-Based Topic Modeling and Identification of Tweets". In: *2021 IEEE International Conference on Progress in Informatics and Computing (PIC)*. IEEE. 2021, pp. 212–218.

[32] Elia Oey, Samuel Samudera Susjanto Harno, and Carolyn Zain. "Developing Integrated Performance Dashboards with Power BI–a Case Study in a Medium-Size Manufacturer". In: *2021 International Conference on Information Management and Technology (ICIMTech)*. Vol. 1. IEEE. 2021, pp. 265–270.

[33] Diogo Pimenta et al. "Monitoring the allocation of European funds in Madeira using dashboards". In: *2021 16th Iberian Conference on Information Systems and Technologies (CISTI)*. IEEE. 2021, pp. 1–7.

[34] Larysa Shaulska, Liudmyla Yurchyshena, and Yurii Popovskyi. "Using MS Power BI tools in the university management system to deepen the value proposition". In: *2021 11th International Conference on Advanced Computer Information Technologies (ACIT)*. IEEE. 2021, pp. 294–298.

[35] Ahmed Al-Sulaiti et al. "Using Data Analytics and Visualization Dashboard for Engineering, Procurement, and Construction Project's Performance Assessment". In: *2021 IEEE 8th International Conference on Industrial Engineering and Applications (ICIEA)*. IEEE. 2021, pp. 207–211.

[36] *Lahore high court*. 2022. URL: https://www.lhc.gov.pk/annual_reports.

[37] *rule of law index*. 2022. URL: https://worldjusticeproject.org/rule-of-law-index/country/2021/Pakistan.

[38] *Supreme court of Pakistan*. 2022. URL: https://www.supremecourt.gov.pk/downloads/?wpdmc=annual-reports.

[39] *what is the rule of law?* 2022. URL: https://worldjusticeproject.org/about-us/overview/what-rule-law.

[40] *wjp rule of law index*. 2022. URL: https://worldjusticeproject.org/our-work/research-and-data/wjp-rule-law-index-2021.

Appendix A

Appendix: Questionnaire for evaluation of Legal Dashboard

Q No 1: What is your age?

1. Under 20
2. 20-30
3. 31-40
4. 41-50
5. 51-60

Q No 2: What is your occupation?

1. Law Student
2. Lawyer
3. Judge
4. Other

Q No 3: How many years of legal experience do you have?

1. No experience
2. 1-5 Years

3. 6-10
4. More than 10 Years

Q No 4: What is your level of comfortability of using a computer?

1. Somewhat comfortable
2. Comfortable
3. Very much comfortable
4. Uncomfortable

Q No 5: How much you are aware of the World Justice Project (WJP)?

1. Somewhat aware
2. Aware
3. Very much aware
4. Unaware

Q No 6: How much an analytics-based solution can be helpful in improving legal decision making?

1. Somewhat helpful
2. Helpful
3. Very much helpful
4. Unhelpful

Q No 7: How much the dashboard is easy to understand for a layman?

1. Somewhat easy
2. Easy
3. Very much easy
4. Not at all easy

Q No 8: How effective are the filters used in the dashboard?

1. Somewhat effective
2. Effective
3. Very much effective
4. Not at all effective

Q No 9: How effectively does the dashboard present different case types?

1. Somewhat effectively
2. Effectively
3. Very much effectively
4. Ineffectively

Q No 10: How effectively does the dashboard presents the status of cases?

1. Somewhat effectively
2. Effectively
3. Very much effectively
4. Ineffectively

Q No 11: How effectively does the dashboard present the implementation of the court's decision?

1. Somewhat effectively
2. Effectively
3. Very much effectively
4. Ineffectively

Q No 12: How much analytics-based solution can be helpful in improving the performance of the judiciary of Pakistan?

1. Somewhat helpful
2. Helpful
3. Very much helpful
4. Unhelpful

Q No 13: What is the level of coverage of legal aspects of the World Justice Project (WJP) in the dashboard?

1. Somewhat covers legal aspects of the WJP
2. Covers legal aspects of the WJP
3. Very much covers legal aspects of WJP
4. Does not cover legal aspects of the WJP

Q No 14: Which aspects of the dashboard need improvement?

1. Legal information being displayed
2. Aesthetics of the dashboard
3. Filters used in the dashboard
4. Legal information and aesthetics
5. Aesthetics and filters
6. Does not need any improvement

Q No 15: What is your level of familiarity with legal research websites i.e., Pakistan-lawsite, indiankanoon, westlaw, and caselaw etc.

1. Somewhat familiar
2. Familiar
3. Very much familiar
4. Unfamiliar