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Chief Editor

Rev. Dr. Dominic Savio, SJ, Principal



St. Xavier's College (Autonomous), Kolkata

30 Mother Teresa Sarani, Kolkata-700016

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Volume 17, January 2025

A Multidisciplinary Journal

“Research is to see what everybody else has seen and think what nobody has thought.”

- Albert Szent-Gyorgyi



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Message from Chief Editor

It gives me immense pleasure in forwarding the 17th volume of “**Aviskaar – A Xaverian Journal of Research**” for the year 2025. This multidisciplinary journal has been successfully published each year since 2009. It bears testimony to the research culture prevailing in our institute.

Aviskaar journal fosters research interest among the faculties of Arts, Science and Commerce of our college. Faculties from different departments can exchange their ideas. Our students, under the guidance of our faculty members have also actively participated in this research endeavour.

I am happy to mention that present volume of Aviskaar journal has contributions not only from our institute, but also from other reputed institutes. Multidisciplinary volume of this year includes quality contributions from the various departments.

I would like to thank all the authors for their contribution. I am also thankful to the panel of reviewers for their valuable comments. Finally, I want to congratulate the editorial team for their hard work to publish this journal successfully in time.

It is noteworthy that research environment of this institute is significantly improving. I strongly believe that this research culture will continue to grow and there will be many more meaningful contributions in the near future.

“Coming together is a beginning, staying together is progress, and working together is success”.
I hope all our faculty members will contribute to this research endeavour to enrich and uplift the quality of the journal.

May God bless you all!

Nihil Ultra.

Rev. Dr. Dominic Savio, SJ



Message from Managing Editor

It is indeed my proud privilege to forward the 17th volume of Aviskaar: A Xaverian Journal of Research. This time there has been lot of modification and we have followed the UGC norms strictly. Under the dynamic leadership of our Fr. Principal Rev. Dr. Dominic Savio, SJ, we have constituted a new research committee comprising of experts from the different domains of Arts, Science, Commerce and Management, which is in line with the UGC norms. The plagiarism check has been done stringently to balance the quality of the journal. The contribution from students is indeed a remarkable aspect, this also speaks about the standard of our students, and it will give them an opportunity to think rationally and carry forward the research career in future.

This volume has been completed successfully and it would not have been possible without the active help of the reviewers and the rigorous exercise carried out by Dr. Tapalina Bhattasali, who not only maintained a perfect coordination between the contributors and the reviewers but also successfully edited the volume. Any word of appreciation is inadequate for her.

Aviskaar provides the quality research platform, where faculties from various departments of our college and researchers from various domains can share their ideas and work together. Professors can also convert projects supervised by them into research papers. It will enhance confidence of our students and help us to show the excellent academic works carried out by our students. I strongly believe that with more and more post graduate departments added to our college, the research culture will take off from this point.

We welcome contributions that can demonstrate near-term practical usefulness, particularly contributions that take a multidisciplinary approach because many real-world problems are complex in nature. We are committed to publishing all discoveries, methods, resources, and reviews that significantly advance the field of research.

“One finger cannot lift a pebble”. “When there is a teamwork and collaboration, wonderful things can be achieved.”

Dr. Arup Kumar Mitra



Message from Associate Editor

First of All, I would like to thank God for giving us the scope to publish 17th volume of Aviskaar: A Xaverian Journal of Research. Our Fr. Principal Rev. Dr. Dominic Savio, SJ always encourages new ideas and contemporary research. I would like to convey my sincere gratitude to Fr. Principal for his kind support. I am also grateful to Dr. Arup Kumar Mitra, Associate Professor of Department of Microbiology and Controller of Examinations for his guidance. Today, I am here only because of them.

I am thankful to all the members of the editorial board. In a special way, I would like to thank Dr. Ayan Chandra, Member Secretary of Academic Council for his valuable suggestions. On behalf of the editorial board, I would like to convey our heartfelt thanks to the internal reviewers, who help us a lot despite their busy schedules. We are also thankful to the external reviewers for their expert opinion.

I am happy to inform you that this issue of the journal includes research outputs from both internal and external researchers. Research is an intrinsic aspect of the idea development process. It helps in guiding numerous decisions that turn an idea into an innovation.

Aviskaar believes in double-blind peer-review process to avoid any type of biasness. It seeks quality contribution from all over the world. *“Many ideas grow better when transplanted into another mind than the one that they sprung up”*. Aviskaar also encourages inter-disciplinary and trans-disciplinary research work.

I firmly believe that “Aviskaar” can show the true research spirit of Xaverian family to the outer world in the near future. If we are together, nothing is impossible.

Let us hope for the best.

Dr. Tapalina Bhattasali

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UNDERSTANDING MOLECULAR DYNAMICS SIMULATION: A REVIEW

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ABSTRACT

Acquaintance with the three-dimensional conformation of a protein and understanding the different parameters and attributes are of tremendous importance in biological research. Proteins can provide us with information regarding the state of the individual, the individual's origin and background and can give us insight on the reactions taking place in the body. It is possible to manipulate protein structure or interactions with other molecules using different methods and substances for the sake of understanding the characteristics and categorization of the protein. To proceed with research on proteins, it is not only important to know the organization of the protein, but it is also essential to know their behaviour in the environments of concern and how they participate in a chemical reaction (enzymatic activity) or interact with other molecules in a coordinated manner, as parts of choreographed metabolic pathways (such as complexation, supramolecular assembly, modifications and synchronization with other proteins). Proteins are also targets to drugs and hence should be meticulously studied prior to drug design. To elucidate the conformational dynamics and extraordinary behavioural and functional diversity of proteins, molecular simulation has been developed. The contributions of molecular dynamics (MD) simulations in research and discovery and designing of drugs are remarkable and their applications have increased in the past few years. These simulations predict behaviour of biomolecules such as proteins considering individual atoms at magnificent miniscule temporal resolution. This report aims in giving a glimpse of the different forces that are acting on a molecule during simulation.

KEYWORDS. *Molecular dynamics simulation; molecule; discretization of time; algorithm; resolution*

1. INTRODUCTION

Molecular dynamics (MD) simulations have gained tremendous importance over years as it can predict and envisage the motion of every atom in a protein or other molecular species over time, with the help from the principles of physics behind such motion and intercommunication (Karplus and McCammon, 2002). These simulations are extraordinarily capable of displaying and analyzing a multitude of essential processes which take place at atomic and molecular levels by demonstrating the possible positions of the atoms or molecules which change over time measured in femtoseconds or picoseconds, such as interatomic and intermolecular interactions, molecular aggregation, polymerization and oligomerization of biomolecules, conformational alterations, folding and modifications of proteins, complexation and supramolecular assembly. Moreover, such simulations are also efficient in elucidating the behavior and discomposure of the biomolecules due to perturbations such as oxidation, reduction, mutations, activity of enzymes or incorporation and dissociation of ligands. MD simulations, along with different experimental methods like advanced microscopy, crystallography, mass spectrometry and spectroscopy can be used, and to obtain a comprehensive knowledge of the characteristics of a molecular species. In addition, electron paramagnetic resonance (EPR) and Förster resonance energy transfer (FRET) can also be used in combination with MD simulation to give meaningful and substantial information about proteins and other important biomolecules (Hollingsworth and Dror, 2018). The fundamental approach of MD simulation is simple. Having the knowledge of the positions of the atoms of a molecular species in a biological system prior to performing MD simulation, one can determine and evaluate the force experienced by an atom due to the impact between that atom and the surrounding atoms. It is therefore possible to use Newton's laws of

motion to compute the position of each atom in three-dimensional space as a time function. The simulation calculates the forces acting on each atom continually and describes the celerity and whereabouts of each atom using those forces. As a result, a trajectory is obtained which is a representation of the arrangement of the system at every single point throughout the time of simulation, in three-dimensional space. These simulations are widely acknowledged for numerous rationales (Hollingsworth and Dror, 2018). Firstly, they take into consideration the motion and position of every atom present in a system at all points throughout the time interval of simulation, which is extremely cumbersome and inconvenient to achieve with any known wet lab technique. Secondly, the parameters of simulation are exactly mentioned and therefore it is possible to conscientiously manipulate and manage them. The conditions of simulation comprise of: which ligands are bound to a protein (or assembly of proteins), its protonation state of a molecule, whether it has any mutations or post-translational modifications (for nucleic acids), the initial conformation of a protein, which other molecules are present in its environment or neighborhood of a molecule, the temperature, the voltage across a membrane (any subcellular compartment), and so on (Hollingsworth and Dror, 2018). Comparison among simulations enables the scientist to recognize the results of different perturbations in the system. The forces considered in MD simulation are reckoned by using molecular mechanics force field, which is a suitable and relevant model for understanding the outcomes of quantum mechanical computation and some experimental measurements. For instance, a quintessential force field uses terms that predict electrostatic (Coulombic) interactions within atoms, spring-like terms that approximate the favorable covalent bond length, and terms expressing plenitude of interatomic interactions. The increasing similarities and resemblances between the data obtained from simulation and experiments suggest the improvement of force fields over time (Lindorff-Larsen et al., 2005), yet they would never attain perfection because of the approximations they make during simulation and hence the incertitude should be taken in regard during interpretation of results. Furthermore, in a classical MD simulation, there is neither formation nor breaking of covalent bonds. Molecular mechanics or quantum mechanics (abbreviated as MM and QM respectively) simulations, is used to model little parts of the system by using quantum mechanical calculations and the remaining parts are modelled by MD simulation. Simulations are commonly used to understand the mechanisms of the reactions which comprise of modifications and alterations to covalent bonds or occur due to the absorption of light (Senn and Thiel, 2009). In MD simulation, each quintessential time step is of few femtoseconds, and this guarantees stability. Important events concerning proteins such as assembly of proteins, post translational modifications, enzymatic activity and interactions with other biomolecules need nanoseconds to microseconds to take place. Some reactions even need milliseconds to take place. Therefore, a simulation comprises of time steps which are femtoseconds each, require millions or sometimes billions of time steps to capture the activity (Hollingsworth and Dror, 2018). A single time step assesses millions of interactions between atoms, which makes evaluation of all the interactions in every time step of the legion throughout the simulation computationally onerous and perpetuating. This challenge had disturbed the scientists as the imprecision had let unanticipated inconvenience to be present in the results of simulation which interfered with the analysis. To circumvent the ramifications which emerge due to the inaccuracy in the simulation, developers have improved the algorithms, the hardware and the software to allow scientists to perform affordable and longer simulations having enhanced precision. Highly developed and customized hardware has significantly increased the speed of simulation, reducing the timescales of certain simulations from minutes to milliseconds (Shaw et al., 2008; Shaw et al., 2014). Advancements in graphics processing units (GPU) have increased the efficiency and reliability of the simulations even in ordinary computers which surpass the simulations which were formerly performed on supercomputers (Salomon-Ferrer et al., 2013). Furthermore, GPUs have made the timescales of simulations relevant, practicable and reasonable and have also made straightforward and undemanding simulations achievable and accessible to many scientists. To address the problems which simple simulations with plain programming cannot confront, advanced and planned simulations have been developed, which however, need comprehensive exploration before one could perceive the standards of such simulations – what can be accomplished and what are the limitations (Salomon-Ferrer et al., 2013). Knowing the limitations can therefore encourage the development of better and more logical algorithms.

2. MOLECULAR DYNAMICS SIMULATION- PRINCIPLE

In molecular dynamics simulation, the interactions between atoms are captured over a period by evaluating the motion of individual atoms and concatenating the motion of all the atoms and presenting the interactions in form of a movie (Karplus and McCammon, 2002). The simulation can predict the new velocities and positions of the atoms with progress of time from a given set of initial velocities and positions using the principles of Newton's laws of motion (González, 2011). The simulation is capable of prognosticating and displaying different motions and incidents experienced by atoms in a biological system, such as, vibrating about a mean position when they are constrained, oscillating in waves together with the adjacent atoms in harmony and concordance, evaporating from a free surface, roaming around in a fluid or colliding with the surrounding atoms. The algorithms of the simulations can therefore give the scientists an idea of the behavior of real atoms in a biological system by calculating their motions (more than one type of motion can take place simultaneously), orientation and trajectories (Brooks et al., 2009). The trajectory of a system is computed in 6N dimensional phase space which comprises of 3 dimensions of position and 3 dimensions of momentum for each atom in that system. A trajectory represents the conformational dynamics of a molecule, and they are obtainable without considerable dissipation of energy (without breaking of bonds). In molecular dynamics (MD), simulation trajectories are critical components that provide detailed information about the motion and behavior of atoms and molecules over time (Phillips et al., 2005). The significance of simulation trajectories in MD can be understood from several perspectives. Trajectories allow researchers to observe and analyse the dynamic behavior of molecules. By tracking the velocities and positions of atoms over time, scientists can gain insights into how molecules move, vibrate, and interact with each other (Hansson et al., 2002; Humphrey et al., 1996; Rapaport, 2004; Frenkel and Smith, 2002). Trajectories also reveal information about structural changes in molecules. Researchers can study conformational changes, transitions between different states, and identify key events such as protein folding or binding events in drug-protein interactions (Hansson et al., 2002; Humphrey et al., 1996; Rapaport, 2004; Frenkel and Smith, 2002). Trajectories provide insights into dynamic properties such as diffusion rates, reaction pathways, and relaxation times. These properties are crucial for understanding the kinetics of molecular processes. The interatomic and intermolecular interactions, hydrogen bonding and van der Waals forces can also be understood from studying the trajectories. Researchers can identify the strength and duration of these interactions during the simulation (Hansson et al., 2002; Humphrey et al., 1996). MD simulations are often used to model the behavior of biomolecules, polymers, and other complex systems (Karplus and McCammon, 2002). Trajectories serve to validate the accuracy of these models by comparing simulated results with experimental data. Consistent trajectories with experimental observations suggest a reliable model. Analysis of trajectories provides valuable information about the thermodynamic properties of a system. This includes temperature, pressure, energy distribution, and entropy (Hansson et al., 2002; Rapaport, 2004; Frenkel and Smit, 2002). Statistical averages derived from trajectories help in calculating these thermodynamic properties. By analyzing trajectories, researchers can refine force fields and improve simulation protocols. This contributes to more precise modelling of the molecule (or system) thus enhancing the predictive capabilities of MD simulations. In drug discovery, MD simulations are used to know how drugs interact with their target biomolecules. Trajectories help identify binding sites, understand binding mechanisms, and predict the stability of drug-protein complexes. In summary, simulation trajectories in molecular dynamics play an important role in elucidating the dynamic and thermodynamic properties of molecular systems (Hansson et al., 2002; Humphrey et al., 1996; Rapaport, 2004; Frenkel and Smith, 2002). They provide a comprehensive view of molecular behavior, aiding in the understanding of complex biological processes, materials science, and drug design.

MD simulation is a suitable technique for optimizing and improving structures by simulated annealing (González, 2011). Simulated annealing reinforces and strengthens the structures of large macromolecules which allows the scientists to study their structural dynamics and the organization and arrangement of the constituents or subunits. It is important to know dynamics because they govern the processes and mechanisms which influence the properties and

functions of biomolecules, such as folding or modifications of a protein or cross linking of constituents in a biopolymer. Interatomic interactions take place due to the manoeuvring of atoms under the action of forces which are exerted on an atom by its neighbors. The forces acting on an atom change as it perpetually moves to a new position. In MD simulation, these instantaneous and prompt forces acting on every atom are considered to execute the simulation of molecular conformational dynamics (Tuckerman and Martyna, 2000). A simulation is generally performed on a system which contains thousands of atoms. So, it requires uncompromising precision and swiftness of the simulation to produce impeccable results, as mentioned earlier. A simulation is genuine and authentic when the time spent on simulation is prolonged compared to the relaxation time of the concerned quantities. As already discussed, simulated annealing makes MD simulation an excellent method for optimization of structures of molecules, we shall now understand how it is achieved. The conventional optimization methods are unable surmount energy barriers which are hindrances in the process of optimization of systems or minimization of energy and the system is reformed according to the energy of the closest local minimum (Tuckerman and Martyna, 2000). In MD simulation, superior optimization is possible by decreasing the temperature gradually to zero which allows the system to overcome the energy barriers and choose and occupy the optimum energy minimum. The lowest of all energy minima is favoured by a system as it is stabilized at lowest energy (entropy is minimum). This is known as simulated annealing in which temperature is initially set at a higher value and then slowly reduced to zero, which decreases the entropy of the system and allows it ensconce the lowest energy minimum. In molecular dynamics based on classical mechanics, Newton's laws of motion are regarded and time steps capturing the motion are integrated and amalgamated to form a movie showing the complete motion of all the atoms in a system, leading to energy conservation (González, 2011; Hansson et al., 2002; Humphrey et al., 1996; Rapaport, 2004; Frenkel and Smith, 2002). From the perspective of statistical mechanics, ensembles such as isobaric-isoenthalpic and microcanonical are used for performing simulations. In isobaric-isoenthalpic ensemble, the volume of the imaginary box enclosing the system is variable, but enthalpy is conserved. On the other hand, the volume, enthalpy and the number of particles is invariable and uniform in microcanonical ensemble. Besides isobaric-isoenthalpic and microcanonical ensembles, canonical ensembles are another important ensemble in which temperature remains unchanged (González, 2011). The time integration algorithms are the fulcrum of the MD simulation, which are based on the definable difference methods. In such methods, discretization of time takes place on a defined and computable grid. The distance between two successive points on the finite grid is the time step, represented as Δt (González, 2011). The algorithm can provide insight on the position and other quantities related to the system later, by knowing the position and other quantities (which are function of time) at a given time. By repeating this process, longer time periods can be covered, which gives the scientists information about the position of the system and other quantities related to it throughout the stipulated time (González, 2011). Discretizing time involves representing continuous time as a series of discrete points or intervals. This process is commonly used in various fields, including computer simulations, signal processing, and control systems. Here are a few methods to discretize time:

- **Uniform Discretization:** A fixed time step (Δt) is chosen, and time is advanced by that amount in each iteration. For example, if one begins at $t=0$ and want to proceed by Δt in each step, then the individual time points would be $t_0=0$, $t_1=\Delta t$, $t_2=2\Delta t$, and so on.
- **Non-Uniform Discretization:** Time steps can vary at each iteration, allowing for finer resolution in critical areas. This is generally useful when simulating systems where events occur at different rates.
- **Fixed Events Discretization:** Time is discretized based on specific events or occurrences rather than fixed intervals. For example, in a simulation, one might update the time whenever a particular condition is met, or an event happens.
- **Adaptive Time Stepping:** The time step is adjusted dynamically based on the system's behavior. For instance, if the system is changing rapidly, one should use smaller time steps to capture the details more accurately.
- **Discrete Event Simulation (DES):** The system is modelled based on events that occur at specific points in time. Time only advances when an event occurs, and the next event is scheduled.

- **Sampling:** In signal processing, time can be discretized through sampling. The continuous signal is sampled at regular intervals to obtain discrete values.
- **Numerical Integration:** Numerical integration methods such as Runge-Kutta and Euler methods inherently discretize time when resolving differential equations. Runge-Kutta method is a commonly used method as it is constructive in solving the initial-value problems of differential equations. It can be used to formulate high order perfect numerical method by self (a parameter in function) without requiring the high order derivatives of functions. These methods approximate the continuous evolution of a system over discrete time steps.

However, there are flaws in these schemes as they are fallible and imperfect. Round off errors and truncation errors are the two types of errors that scientists come across in MD simulation. Round off errors arise due to inaccurate execution of the algorithm (for example, related to the number of digits which are used by the computer to perform pertinent arithmetical functions) whereas truncation errors are inherent to the algorithm and occur due to the inaccuracy of the finite difference procedure with regard to the real system (González, 2011; Hansson et al., 2002; Humphrey et al., 1996; Rapaport, 2004; Frenkel and Smith, 2002). One way of minimizing these errors is by reducing the time step (Δt). The time integration algorithms preferred for MD simulation are Verlet algorithm and Predictor-corrector algorithm (Leach, 1996). The predictor-corrector algorithm uses Taylor expansion to predict the position and quantities which are function of time (for example, acceleration) from the initial position and time derivatives of the atoms of a system, at a time which is one- or several-time steps (Δt) ahead of the starting time of the simulation (t). This is the first of the three steps followed by the algorithm while performing MD simulation. In the second step, the force is evaluated by ascertaining the potential gradient of the positions and other quantities anticipated in the first step, which allows the algorithm to calculate the actual quantities and positions at that time. The difference between the computed quantity and predicted quantity (for example, acceleration) gives rise to the error. In the last step, the positions and other quantities are rectified proportionally to the error signal, that is, completely diminishing the difference between the computed and predicted position of an atom or group of atoms interacting with each other or any other time dependent quantity related to the atoms. The proportionality coefficient is determined to make the algorithm more stable and robust (Leach, 1996). The Verlet algorithm is more popular and used more often than the predictor-corrector algorithm. The fundamental concept of Verlet algorithm is to update the positions and velocities of particles in discrete time steps based on their current positions, previous positions, and forces acting on them. The algorithm is especially useful for problems where the forces are dependent on a potential energy function (Leach, 1996). The Verlet algorithm is a numerical method commonly used in physics simulations, particularly in molecular dynamics and computational physics, to solve equations of motion for a molecule or a system. It is known for its stability and conservation of energy, making it suitable for simulating physical systems over time. The Verlet algorithm not only ensures splendid numerical stability, but also provides stability to important parameters such as reversibility of time and symplecticity of the phase space. Compared to the Euler method, Verlet algorithm provides stability to the parameters without expenditure of extra computational cost (Leach, 1996). The leap frog algorithm is a modified form of the Verlet algorithm. The difference between the two algorithms is that the velocities and positions are not calculated concomitantly. The velocities and positions are calculated sequentially at interleaved time points, emblemizing leapfrog. To begin a simulation, the initial position and velocity (quantity which is a function of time) for an atom should be provided to the algorithm (González, 2011). The initial velocity of an atom is obtained from Maxwell distribution at a specific temperature, whereas the initial position is obtained either from an experimentally determined structure or from a well-established and thoroughly scrutinized computational model. If two consecutive simulations are performed on the same molecule, then the final positions and velocities of the atoms of the previous simulation can be used as the initial positions and velocities for performing the following simulation (Haile, 1992). With reference to the ensembles mentioned above, the size of the box in which a molecule or a system is placed during MD simulation is approximately two times of the largest dimension of the molecule or the system (González, 2011). The molecule (or the system) is solvated by encompassing it with molecules of water or any other solvent within the box, keeping in mind that there should be no contact between any atoms. When the simulation begins, there is a change in the state of

the molecule (or system), which causes disequilibrium in the molecule (or system) for a while. The molecule (or system) should achieve equilibrium before making calculations. A physical quantity achieves equilibrium over time, and this is measured by τ (tau) (González, 2011). Tau is generally of hundreds of time steps which allow the scientists to witness the achievement of equilibrium by the quantity over time. As time advances the approaching of the physical quantity towards equilibrium gets augmented. The simplest way to analyze a molecule or system is to observe it during or after the completion of the simulation. It is possible to assign radii, shapes and sizes to the atoms to make aid in analysis. Atoms can also be given colors based on their properties such as charge (Gavezzotti, 2007). Sophisticated programs have been developed to take photographs of the molecule (or system) to perceive infinitesimal changes in them which are otherwise impossible to discern and recognize by simply looking at them during or after the simulation (Gavezzotti, 2007).

3. PERFORMING MOLECULAR DYNAMICS SIMULATION

To perform or execute MD simulation, there are four steps. The four steps are as follows:

3.1 Setting Up System

This step considers majority of the aspects. It is required to intelligently and judiciously configure the interested system, select the force field which is most suitable and reasonable for the system, choose an appropriate cut-off radius and select a proper and effective method to explore the electrostatic interactions in a system comprising of partial charges, opt for an accurate time step and a relevant integration algorithm (the selection of an integration algorithm is possible only if the code used by the scientists empowers them to do so), and choose a suitable ensemble for performing the simulation. Any simulation captures the physics behind molecular interactions. So, it is essential that a scientist is aware and confident of the size of the system which should be adequate to comprehensively and uncompromisingly capture the physics behind the interactions. For instance, as discussed earlier, if a person wants to study about the different interatomic interactions or conformational dynamics within a molecule or a group or assembly of molecules of size A , then the minimum size of the box should be twice of the size of the molecules ($2A$). Likewise, to study propagation of sound in a liquid, L should be considerably sizeable so that low values of Q can be obtained, and these low values of Q correspond to a spectrum which exhibits a magnificently resolved Rayleigh-Brillouin triplet (Encisco et al., 1995).

3.2 Equilibration

Generally, the inception configuration does not represent the conditions which a scientist wants to explore. For instance, it is required to change the conditions of simulations from a previous MD simulation, such as change in temperature. It should be considered that if the starting positions are arbitrarily chosen then there will be some atoms which are very close to one another or there will be no long-range correlations, and this is not real. If the scientists begin with an organized and systematic configuration and are interested in liquid, melting of the system is required so that evanescence of long-range order is ensured. Generally, NPT simulation is required for this step as this simulation allows the system to attain equilibrium density related to the preferred temperature and pressure. It is not important to choose a thermostat or barostat as no property will be computed using this part of the simulation. It is essential that an equilibrated state is accomplished, therefore, in this phase, density, pressure and various components of energy which remain around an average value without exhibiting substantial deviation at equilibrium, should be followed. It is also possible to evaluate the development and progression of rotational (gyratory) and/or translational order parameter if melting of the lattice organization with which the simulation was started (Allen and Tildesley, 1987). It is feasible to demonstrate that properties like mean square displacement or radial distribution function are not dependent on the part of the trajectory which is used for their evaluation. Also, this will happen if the part of the trajectory is of decent length to support ergodic hypothesis. According to ergodic hypothesis, the ensemble average concurs with the time average of a particular feature. Although this hypothesis is germane to majority of the cases, especially when a crystal or a liquid

is simulated, it is not relevant to some systems (for example, glasses) and in non-ergodic systems the results depend on the system's history (Frenkel and Smit, 2002).

3.3 Production

The production run is performed when equilibrium is achieved at the preferred pressure and temperature. The effects of barostat or thermostat should be avoided and therefore working in the NVE ensemble is the most suitable. However, the temperature drifts occurring in lengthy simulations due to the truncation effects can be problematic. In such cases, thermostats should be applied. Generally, a barostat is not used because the pressure should be practically around the mean value attained during equilibration. Therefore, no problems will arise while working with a fixed cell as the problems arising due to fluctuations in volume during interpretation of a trajectory can be avoided. An exception to this is a special case where a phase transition needs to be simulated (Parrinello and Rahman, 1980; Martonák et al., 2003). The time period of the simulation should be predetermined. A simulation should run for a time which is much longer compared to the relaxation time of the attribute of concern. Also, the simulation time should be considerably long so that ergodic hypothesis remains valid. When a large biomolecule (like a protein) which can attain various conformations is studied, the time for the simulation should be sufficient to allow exploration of all the conformations possible at a given condition, because if the time is short, the displacement of that atoms throughout the simulation might reflect one of global conformations of the biomolecule instead of the actual situation.

4. ANALYSIS

To know about the interested properties, the trajectory which has been simulated needs to be comprehensively scrutinized. As the simulation provides the scientists the knowledge of the velocities, positions of the atoms and the forces which are functions of time, they can compute all those statistical mechanical properties which are defined by those variables. The various quantities generally computed and analysed are atomic mean square displacement, radial distribution function, pressure and temperature which are classified under dynamical, structural and thermodynamic properties respectively (Calandrini et al., 2011).

5. CONCLUSION

The applications of MD simulation are increasing day by day as scientists are interested in knowing how atoms behave in real world. Molecular Dynamics simulation gives information on the changes in behaviour of atoms over time. The different forces acting on the atoms are taken in account by the algorithm to produce logical and accurate simulations which depict changes in atoms as time advances. However, some forces acting on the atoms are vaguely known and therefore could not be considered by the simulation algorithms. To understand those forces meticulous research is required and advanced algorithms should be developed to revolutionize simulations. Although simulations can be verisimilar, we should keep in mind that a simulation can never be identical to what happens in real world. Therefore, simulations are always associated with wet lab experiments to gain enlightenment on the behaviour and interactions of atoms. Simulation have contributed to molecular research by showing those changes to the scientists which would otherwise have remained unacknowledged. Due discretization of time, MD simulations can even predict unique, exiguous or rare events which would otherwise have taken years to come to the limelight. Due to the advantages MD simulation, it is widely used in designing drugs and studying biochemical reactions and pathways. More research in particle physics, surface chemistry, thermodynamics and statistical mechanics, in combination with advancements in programming can make MD simulation the best computational method to know about the behaviour and interactions of atoms.

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REFERENCES

1. Allen, M. P., and Tildesley, D. J., (1987) Computer simulation of liquids, *Oxford University Press*.
2. Brooks, B.R., Brooks, C.L., III, Mackerell, A.D., Jr., Nilsson, L., Petrella, R.J., Roux, B., Won, Y., Archontis, G., Bartels, C., Boresch, S., Caflisch, A., Caves, L., Cui, Q., Dinner, A.R., Feig, M., Fischer, S., Gao, J., Hodoscek, M., Im, W., Kuczera, K., Lazaridis, T., Ma, J., Ovchinnikov, V., Paci, E., Pastor, R.W., Post, C.B., Pu, J.Z., Schaefer, M., Tidor, B., Venable, R.M., Woodcock, H.L., Wu, X., Yang, W., York, D.M. and Karplus, M., (2009) CHARMM: The biomolecular simulation program, *J. Comput. Chem.*, 30, pp. 1545-1614. <https://doi.org/10.1002/jcc.21287>
3. Calandrini, V., Pellegrini, E., Hinsen, K., and Kneller, G. R., (2011) nMoldyn - Interfacing spectroscopic experiments, molecular dynamics simulations and models for time correlation functions, *Collection SFN*, 12, pp. 201–232, 10.1051/sfn/201112010
4. Enciso, E., Almarza, N. G., Domínguez, P., González, M. A., & Bermejo, F. J., Dynamic structure factor of a helium-neon dense gas mixture: Crossover from hydrodynamics to the microscopic regime, *Phys. Rev. Lett.*, 1995, 74(21), pp. 4233–4236, <https://doi.org/10.1103/PhysRevLett.74.4233>
5. Frenkel, D., and Smit, B., Understanding Molecular Simulation - *Academic Press*, 2002.
6. Gavezzotti, A., Molecular Aggregation: Structure analysis and molecular simulation of crystals and liquids, *Oxford University Press*, 2007.
7. González, M. A., Force fields and molecular dynamics simulations, *Collection SFN*, 2011, 12, pp. 169-200, 10.1051/sfn/201112009.
8. Haile, J. M., Molecular dynamics simulation: Elementary methods, *Wiley-Interscience*, 1992.
9. Hansson, T., Oostenbrink, C., & van Gunsteren, W., Molecular dynamics simulations, *Current opinion in structural biology*, 2002, 12(2), pp. 190–196. [https://doi.org/10.1016/s0959-440x\(02\)00308-1](https://doi.org/10.1016/s0959-440x(02)00308-1)
10. Hollingsworth, S. A., & Dror, R. O., Molecular dynamics simulation for all, *Neuron*, 2018, 99(6), pp. 1129-1143, 10.1016/j.neuron.2018.08.011
11. Humphrey, W., Dalke, A., & Schulten, K., VMD: visual molecular dynamics, *J. Mol. Graph.*, 1996, 14(1), pp. 28-33 [https://doi.org/10.1016/0263-7855\(96\)00018-5](https://doi.org/10.1016/0263-7855(96)00018-5)
12. Karplus, M., & McCammon, J. A., Molecular dynamics simulations of biomolecules, *Nature structural biology*, 2002, 9(9), pp. 646–652. <https://doi.org/10.1038/nsb0902-646>
13. Leach, A. R., Molecular modelling: Principles and applications, chapter 3: Empirical force field models: molecular mechanics, *Addison Wesley Longman Limited*, 1996, pages 196–204.
14. Lindorff-Larsen, K., Best, R. B., Depristo, M. A., Dobson, C. M., & Vendruscolo, M., Simultaneous determination of protein structure and dynamics, *Nature*, 2005, 433(7022), pp. 128–132, <https://doi.org/10.1038/nature03199>
15. Martonák, R., Laio, A., & Parrinello, M., Predicting crystal structures: the Parrinello-Rahman method revisited, *Phys. Rev. Lett.*, 2003, 90(7), 075503. <https://doi.org/10.1103/PhysRevLett.90.075503>
16. Parrinello, M., and Rahman, A., Crystal structure and pair potentials: A molecular-dynamics study, *Phys. Rev. Lett.*, 1980, 45, pp.1196–1199, <https://doi.org/10.1103/PhysRevLett.45.1196>
17. Phillips, J. C., Braun, R., Wang, W., Gumbart, J., Tajkhorshid, E., Villa, E., Chipot, C., Skeel, R. D., Kalé, L., & Schulten, K., Scalable molecular dynamics with NAMD, *J. Comput. Chem.*, 2005, 26(16), pp. 1781–1802. <https://doi.org/10.1002/jcc.20289>
18. Rapaport, D. C., The art of molecular dynamics simulation, *Cambridge University Press*, 2004.



19. Salomon-Ferrer, R., Götz, A. W., Poole, D., Le Grand, S., & Walker, R. C., Routine Microsecond Molecular Dynamics Simulations with AMBER on GPUs. 2. Explicit Solvent Particle Mesh Ewald, *J. Chem. Theory Comput.*, 2013, 9(9), pp. 3878–3888, <https://doi.org/10.1021/ct400314y>
20. Senn, H. M., & Thiel, W., QM/MM methods for biomolecular systems, *Angewandte Chemie* (International ed. in English), 2009, 48(7), pp. 1198–1229. <https://doi.org/10.1002/anie.200802019>
21. Shaw, D. E., Deneroff, M. M., Dror, R. O., Kuskin, J. S., Larson, R. H., Salmon, J. K., Young, C., Batson, B., Bowers, K. J., Chao, J. C., et al., Anton, a special-purpose machine for molecular dynamics simulation, *Commun. ACM*, 2008, 51, pp. 91–97. <https://doi.org/10.1145/1364782.1364802>
22. Shaw, D. E., Grossman, J. P., Bank, J. A., Batson, B., Butts, J. A., Chao, J. C., Deneroff, M. M., Dror, R. O., Even, A., Fenton, C. H., et al., Anton 2: raising the bar for performance and programmability in a special-purpose molecular dynamics supercomputer, *Proceedings of the International Conference for High Performance Computing, Networking, Storage and Analysis* (IEEE Press), 2014, pp. 41–53.
23. Tuckerman, M. E., and Martyna, G. J., Understanding modern molecular dynamics: Techniques and applications, *J. Phys. Chem. B*, 2000, 104, pp. 159–178, 10.1021/jp992433y

ANALYSIS OF THE ISSUES AND DIFFICULTIES BY ANTHROPOGENIC ACTIVITY EFFECTS ON BIODIVERSITY: A CASE STUDY AT PATHIRAMANAL ISLAND

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ABSTRACT

Pathiramanal, an exquisite tiny island in Kerala's Vembanad Lake, is a popular destination for nature lovers. However, human activity has put this migratory bird paradise at risk of annihilation. The Thannermukkam Saltwater Barrage (1975) and other anthropogenic interventions have led to biodiversity loss, including decreased plant diversity, spiders and ants, fish mortality, weed growth, and water quality. The study is an attempt to investigate biodiversity and habitat loss for the island's plants and animals, water pollution, environmental degradation, plastic waste issues, and physical-chemical changes in the hydro source of Vembanad Lake. Data were gathered from both primary and secondary sources, with a focus on secondary sources on pollution, its consequences on the ecology, and the potential for responsible tourism. The results show that since the Thannermukkam Regulator cum Bridge was put into service in 1975, Pathiramanal Island's biodiversity has undergone significant change, and the island's plant and animal species are struggling to survive due to human activities. Because of the regulator cum bridge, agricultural reclamation, encroachments, replenishment, and landfilling by humans for habitat, and tourism uses, the lake's water holding capacity has dropped from 2.4 km³ to 0.6 km³. Microplastics and heavy metals like cadmium and lead are among the pollutants that pose a threat to biodiversity. To preserve the island's biodiversity and natural beauty, the study recommends responsible tourism practices and the execution of a sustainable development plan with a high ecological concern.

KEYWORDS. *Anthropogenic Interference; Water Pollution; Bio-Diversity; Ecology; Preservation; Responsible Tourism; Sustainable Development*

1. INTRODUCTION

Alappuzha, the jewel in the crown of Kerala, is well known for its breathtaking beaches and backwaters, a system of lakes and brackish lagoons running parallel to the Arabian Sea coast. The largest lake in Kerala is the Vembanad Lake, also known as Punnamada Kayal (near Kuttanad), Kochi Kayal (in Kochi), Vembanad Kayal, and Vembanad Kol. It is situated between the districts of Kottayam and Alappuzha. It runs through 2033.02 km² and connects the Kerala districts of Kollam, Ernakulam, and Alappuzha, Kottayam. The Meenachil, Achankovil, Pampa, and Manimala are the four major rivers that supply water to the lake.

Pathiramanal Island in the Vembanad Lake is a refuge for migratory birds. This little, uninhabited island falls under the jurisdiction of the Muhamma Grama Panchayath of the Alappuzha District. However, it is a part of Kottayam Wildlife and Forest Division because it is a restricted and conserved region. Not only does it have no private property to it, but there are now no civilian residents. It has a 28.505 hectares' total area. It covers an area of 13 kilometers and 1.5 km away from Muhamma Boat Jetty. The island was formerly leased to private company owners, but Kerala's tourism department currently has direct control over it. Tourists and bird watchers are only allowed to visit the island during the daytime hours due to the lack of housing and electricity. The island is home to exceptional plants like *Aponogeton appendiculatus*, *Macuna Gigantea*, *Flagellaria Indica*, and mangrove variety. Mussel colonies of *Villorita* species grow near the island, and therapeutic plants like *Calophyllum Inophyllum* and *Tylophora Indica* are also found. There is 98 bird species, 34 butterfly species, 160 plant species, 55 fish species, and 23 spider species.



Fig 1. Vembanad Lake

2. PATHIRAMANAL: HISTORICAL AND MYTHOLOGICAL ALLUSIONS

The term Pathiramanal factually refers to 'midnight sand'. As per the folk myth, during one of his overnight water journeys across Vembanad Lake, the renowned Brahmin Vilwamangalathu Swamikal dove into the lake to perform his evening ablutions. As a result, the water made way for land to rise from below, creating the charming island of Pathiramanal (sands of midnight). The island was also known as Anantha Padmanabhan Thoppu. History paints a different tale. A landowner by the name of Parayi Tharakan owned the island. He sold it to Bheemji Devji, a Gujarathi trader from Kochi. Subsequently, Chevalier ACM Anthraper assumed control of the coconut plantation there after purchasing the land from M/s. Bheemji Devji Trust of Cochin. During that period, fourteen laboring families claimed the island home. With the enforcement of the Kerala Land Reforms Act, 1963, the excess land in the possession of the family was identified. The Island was one of the lands surrendered by the family in favour of the Government. As a result, the Department of Tourism eventually received possession of the property from the government. As of right now, no one lives on the island. After the 14 families in Muhamma Panchayat received rehabilitation, the island progressively turned into a refuge for migrating birds.

The island has become a roosting site for aquatic birds, primarily cormorants, due to the low level of human disturbance. The darter, Indian Shag, Purple Heron, Indian Pond Heron, Cattle Egret, Grey Heron, Large Cormorant, Night Heron, Black Bittern, Chestnut Bittern, and Yellow Bittern, as well as Little, Median, and Large Egrets, were among the other birds sighted. There are other birds that live on the island, such as Common Teals, Pheasant-tailed and Bronze-winged Jacanas, Stork-billed Kingfisher, Whistling Duck, Cotton Pygmy Goose, Whiskered Tern, and Smooth Indian Otters (*Lutra lutra*). European and Siberian migratory birds like the waterways between the tiny island and the Kumarakom Bird Sanctuary.

3. BACKGROUND OF THE STUDY

As part of its Golden Jubilee celebrations, St. Michael's College, Cherthala has started long-term activities against plastic pollution in Vembanad Lake. At Pathiramanal Island, the NSS unit has been active in cleaning and awareness programs, involving stakeholders, assessing pollutants, and erecting hoardings. Every year on September 24, which is National Service Day, the NSS unit works with the District Panchayath and the District Tourism Promotion Council to clean up and spread awareness about plastic pollution in Vembanad Lake and Pathiramanal Island. During the cleanup drive, it was observed that the amount of plastic rubbish on and surrounding Pathiramanal Island is increasing year after year. NSS volunteers raised the question of how and why there is so much plastic waste in this area of Vembanad Lake. They investigated the disposal of plastic and other rubbish, as well as the piles of waste on Pathiramanal Island. The findings indicate that unethical human interventions and tourist activities in Vembanad Lake, which violate responsible tourism standards, are the primary causes. This rubbish disposal eventually pollutes the water and endangers the environment of Vembanad Lake and Pathiramanal Island. Following that, as the Programme Officer of the NSS unit, the current investigator began follow-up research into the topic of pollution and environmental issues in Pathiramanal Island and Vembanad Lake, as well as the necessity for responsible tourism.

4. OBJECTIVES OF THE STUDY

The prime intend of this work is to examine the primary aspects contributing to water pollution and environmental degradation in Pathiramanal Island and Vembanad Lake. It also sought to evaluate the problems of plastic waste at Pathiramanal Island and the degree of water pollution in Vembanad Lake. The other intent of the study is to determine how well responsible tourism may reduce Pathiramanal Island's pollution issues.

5. MATERIALS AND METHODOLOGY

Owing to its dense vegetation and extensive forest cover, Pathiramanal Island, a small tropical island in Kerala, our land, is abode to a diverse range of flora and wildlife. Spiders make up a sizable portion of the island's population. In 1979, the Kerala Government seized ownership of the land and gave it to the Department of Tourism. This study on Pathiramanal Island's biodiversity and the problems caused by man-made pollution was carried out between October 2018 and September 2020. Using the historical research approach, the data was gathered from primary and secondary sources up to the present day. After examining and evaluating published works, media reports, investigation outputs, and databases from consultancies and non-governmental organizations involved in Vembanad Lake water pollution and environmental issues, the researchers decided to employ the qualitative technique.

To arrive at reliable references, the secondary sources pertaining to responsible tourism are also examined. To contribute creative insights on the themes and to complement the thematic analytical findings of the researchers, tourism officials and industry operators were consulted via social media platforms and email. For ecosystems to remain healthy and function well, ecological sustainability is essential. Seventeen sustainability challenges that have an impact on the livelihood of fishermen in ten areas were found in a research conducted using the Multi-Dimensional Scaling (MDS) technique. Climate change, overfishing, unsustainable fishing, Thannermukkam barrage, dredging, mangrove depletion, excessive weed growth, shrinkage from sand mining and reclamation, fertilizers and pesticides, oil spills, backwater tourism, and bird attacks are some of these challenges.

6. ECOLOGY OF PATHIRAMANAL ISLAND

Pathiramanal Island boasts a towering biodiversity, a large waterfront, floating weeds, coconut palms, and uncommon wildlife, all contributing to its healthy ecosystem. A large variety of arachnids, including spiders, can be found on the island, greatly enhancing its biodiversity. Even though 23 spider species have been unofficially named, many more remain unexplored, emphasizing the necessity for thorough exploration to fully grasp the island's potential and protect spider species (Devi, 2009). Travelers should be aware that the venomous spider *Loxosceles rufescens* is present on Pathiramanal Island, which accounts for 10% of the overall species diversity, 22% of the total genus diversity, and

43% of the total family diversity, according to specific studies. The majority of the island's green vegetation is made up of mangroves. Mangroves and their associates make up 28% of the total, with non-mangrove trees accounting for 72% (Satheeshkumar et al., 2011). More than 22% of the island's territory is covered in herbs, which come in 107 variations among 23 families. There are 64 families and a total of 169 plant species known from the island. Of these, seven trees and nine species of herbs that grow along the island's shoreline are listed as endangered.

The inland vegetation's tree community was represented by 23 species. The shrub community of the coastline vegetation was comprised of thirty species. The herbaceous layer of the seashore is comprised of 31 species, comprising 23 seedling plants, three grasses, and five herbs. There were eighteen species in the inland herbaceous vegetation, which included two grasses, thirteen seedling plants, and four herbs. This island is a haven for birdwatchers, drawing in a variety of uncommon migratory birds from all over the globe. Winter, from November to March, is the greatest time to watch these birds. The island is also home to resident species, including owls, woodpeckers, parrots, and cuckoos. There are 10 amphibian species, including the Malabar Gliding Frog, Golden Frog, and Common Tree Frog. Bush frogs are heard during monsoon months, but common species like *Hoplobatrachus tigerinus* and *Euphlyctis hexadactylus* are declining (Malamel & Sudhikumar, 2020). This region has 23 reptile species, including *Tesdudines* (turtles and tortoises) and *Squamata* (lizards and snakes). Five lizard species, Southern Green Calotes, Monitor Lizard, and 15 snake species are reported. Wetland dwelling snakes like Checkered Keelback, Siebold's Smooth Water Snake, and Dog-faced Water Snake are well represented. Poisonous snakes are also present.

7. ENVIRONMENTAL CONCERNS

The island remained unorganized until the late 20th century, with the state tourism department taking over. In the 1990s, a boat service was introduced, and the island was declared an eco-tourist place. Due to human influence, the Pathiramanal section of Vembanad Lake is undergoing significant ecological changes. There are a lot of foreign, domestic, and local tourists visiting the island, however there aren't any basic facilities for them. Furthermore, a buildup of plastic and biological garbage was left on the island as a result of neglecting to check on plastic and other debris (Remani et al., 2010). The area is seeing higher levels of turbidity, high levels of chlorophyll, and enhanced organic productivity as a result of the rise in backwater tourism. High amounts of plant nutritional elements have been found in fish, sediments, soil, water, grain, straw, and clams. These elements include phosphates, nitrates, and nitrites. The biodiversity and ecology are threatened by contaminated lake water from disposal of plastic and organic garbage. This leads to widespread pollution, resource depletion, and worker health issues. Studies show the effects of organic and industrial pollutants on benthic populations in the backwaters.

Table 1. Endangered Species of Birds

Sl. No	Species Name	Family
01	<i>Pelecanus philippensis</i> (Spot billed pelican)	Pelecanidae
02	<i>Anhinga melanogaster</i> (Oriental darter)	Anhingidae
03	<i>Gallicrex cinerea</i> (Water cock)	Rallidae
04	<i>Gelochelidon nilotica</i> (Black billed tern)	Laridae

Pathiramanal Island is habitat to approximately 90 kinds of migratory and resident birds, including rare and endangered species like the purple heron and Indian darter. Nevertheless, four bird species have completely vanished from the Pathiramanal and Vembanad regions because of ecological shifts and changing environmental conditions.

Table 2. Endangered Species of Fish

Sl. No	Species Name	Family
01	<i>Labeo dussumieri</i>	Cyprinidae

02	Horabagrus brachysoma	Bagridae
03	Gonoproktopterus curmuca	Cyprinidae
04	Wallago attu	Siluridae
05	Nandus nandus	Nandidae

Thirteen new native fish species, three species of shellfish, and two foreign genus (Sutchi catfish and Sucker catfish) were found in Vembanad Lake according to the 2009 fish count (Joseph et al., 2018). The Thannermukkam saltwater barrier resulted in the introduction of eight estuary species, whilst five were common riverine species (Ashok Trust Report, 2009). Five species—Walking catfish, Indian mottled eel, and Indian shortfin eel—vanished (Table 2). Numerous factors contribute to the environmental alterations and ecological harm occurring in Vembanad Lake and Pathiramanal Island. The most detrimental and unavoidable aspect of this degradation is manmade interventions, such as pollution from plastic and organic garbage dumping and other careless human actions.

Reports show Vembanad Lake's total area decreased from 44,000 ha in the 19th century to 21,000 ha in the 20th century, highlighting human intervention in the lake's ecology.

Table 3. Shrinkage of Vembanad Lake due to Anthropogenic Interference

Time	Reclaimed Area (@ hectares)	Percentage of Area	Function
1833 - 1905	2226.71	6.186	Farming Activities
1910 - 1930	5252.15	14.593	Farming Activities
1940 - 1950	1326	3.67	Farming Activities
Up to 1970	5100	14.165	Paddy cultivation
1969 - 1985	800	2.223	Paddy cultivation
1900 - 1985	1500	4.165	Shelter, farm etc
Up to 1975	6900	19.167	Thannermukkam Bund
1979 - 2010	350	0.971	Super tanker berth
Till 2020	800	2.223	Resorts and Tourism development
Total	24254.86	67.372	

Source: Kurup (2006) & Archival Reports of Kerala Land Board

It is projected that anthropogenic interference has reduced the size of Vembanad Lake by 24254.87 hectares (67.371%) since 1834. The respondent fisherfolk argue that indiscriminate reclamation by national and regional governments or classified parties has reduced shrimp nursery ground and altered estuary features, affecting fishery wealth. Resorts have been established on the lake side in Thannermukkam and Muhamma villages, affecting the lives of fisherfolk and causing issues related to fishing activities. Resort proprietors have erected large fortifications around the resorts, forbidding many services accessed by the fisherfolk. Sand mining in Vembanad wetland ecosystem is causing ecological changes, affecting fisherfolk's catches and income. The sand bed is crucial for fishery life and clam production, but mining dwindles wealth and threatens endemic and endangered species. Bird attacks, particularly the Neerkakka bird, are also causing concern due to changing bird migratory patterns and global climate change.

Ecological Sustainability Index

Ecological sustainability refers to maintaining stocks and species in the environment without compromising future options, enhancing the capacity and quality of ecosystems and environments. Because the loss of harvestable fish results in lower fishing revenue and longer fishing seasons, fishermen view the health of the ecosystem and the

availability of fisheries resources as critical to their ability to secure a living. In Kerala, the insensate management of the state's fragile ecology, particularly coastal ecosystem, has contributed to resource depletion and destruction. The Multi-Dimensional Scaling (MDS) technique is used to portray the seventeen sustainability issues that have an impact on the livelihood of fishermen in ten different regions. The goal of multidimensional spatial point arrays reflecting the subjective distances measured by surveying participants is to represent subjective qualities in objective scales using the Multidimensional Distance System (MDS). The fundamental premise of multidimensional scaling (MDS) is that stimuli can be represented by values across a set of dimensions, and that the distances between equivalent points in the space of multiple dimensions are inversely related to the similarity of stimuli. The pattern of proximity among various opinions is visually represented by MDS, enabling interpretation beyond the scope of the approach.

Table 4: Ecological Sustainability Index
(Production alters in fish and clam supply of Vembanad Lake)

	1985-1999	Up to 2020	Share	The critical minimum	Comment
Fish hold alter	7202 t	686t	0.1	1	Far below the critical minimum
Vembanad Attukonju Macrobrachium (Rosenbergii)	1969	2001	Share	Critical minimum	remark
Catch Alter	439t	28t	0.06	1	Very below the critical minimum
Lime Shell collection alter	1991-95	1996-98	Share	The critical minimum	remark
White crust shell	104590 t	85315 t	0.81	1	Very low
Black crust shell	30772 t	29383 t	0.95	1	Very low
Total	135365 t	114699 t	0.85	1	Very low

Table 5. Ecological Sustainability Index (Fish Species)

Fish diversity alter	1990	2020	Share	Range	Remark
Reduction in fish diversity	149	66	0.434	1	Very low

Table 6. Ecological Sustainability Index (Sector wise - bird count)

Reduction in birds count	1995	2020	Ratio	Range	Comment
Vembanad Wetland	36489	27393	0.752	1	Very low
Vembanad Lake Region	25186	6712	0.265	1	Very low
Thannermukkam Bund Region	1422	287	0.201	1	Very low

The lake's shoreline zone is impacted by several issues, including soil erosion, mangrove destruction, marsh shrinkage, loss of arable land, water pollution, fish catch decline or stagnation, species extinction, and biodiversity loss. The production of fish, prawn, and clam resources in Vembanad Lake shows a devastating declining trend, with the number

of species declining from 150 in 1989 to 65 in 2020. Water birds, which are ecologically dependent on wetlands, are another indicator of the richness and diversity of these productive ecosystems. Coconut husk retting activities in Kerala's distinctive backwater system are very ecologically dangerous for biological production and biodiversity, negatively impacting the livelihood of impoverished fishermen and advocating against retting in backwaters.

Overexploitation, inadequate natural recruitment, habitat alternation, and human meddling are posing a threat to Kerala's indigenous fishing resources. Strategies including open ranching, habitat enhancement, open water culture, and protected sanctuaries have been suggested as solutions to this problem. Producing economically valuable fish species' seeds in hatcheries and the releasing of them into public water bodies is known as "open ranching." In open waters, this technique can greatly increase fish productivity, especially when it comes to the decrease of Vembanad denizer macrobrachium rosenbergii.

Table 7: Ecological Concerns with Vembanad Lake

Tally of faecal coliform	WHO Regulations	Actual	Surplus	Share	Optimum	Remarks
Upstream region	100ml water /350 faecal coliform	15020 per 100ml	14650	0.976	0	Surpassed the limit
Small stagnant channels of Kuttanad	"	130000 per 100 ml water	129650	0.997	0	"
Alleppey channels station	"	38000 per 100ml	37650	0.991	0	"
From water samples of Vembadnad lake	"	31000 per 100 ml water	30650	0.989	0	"
Water carrying capacity of the lake	Beginning of 20 th century	1985	Share	Range	Remark	
	2.449Km ³	0.559Km ³	0.245	1	Very low	
Coconut husk retting area of the lake	Recommended	Real	Over limit	Ratio	Optimum	Remark
Portion of lake under retting	0	246 ha	246	1	0	Surpassed the limit

Source: Primary Source

When it comes to the island's current tourism activities, inadequate upkeep and non-scientific operations are to blame for the deterioration of the ecology and water quality. The Thannermukkam regulator-cum-bridge is the most damaging anthropogenic intervention in Vembanad Lake. The water pollution in Pathiramanal and Vembanad Lake is exacerbated by the excessive use of pesticides and industrial affluent (Nair et al., 2013). Houseboat tourism has significantly polluted Vembanad Lake, depleting fish stocks and livelihoods of 5,000 inland fishermen and clam collectors.

Discussion: Pollution Hazards

Micro-plastic pollution of Vembanad Lake has been extensively documented by research conducted on the lake and its ecosystem, particularly in the Pathiramanal region. Micro-plastic particles found in the lake's sediments are a serious hazard to the fish and clam populations in the area food chain (Ganesan et al., 2019). Low density polyethylene (LDPE) was the most prevalent polymer detected in all sediment samples taken from ten locations, including the area around Pathiramanal Island, containing micro-plastics. The bulk of micro-plastics were found as shards, films, and foam, indicating that larger plastic debris as well as personal care goods was where they came from. The majority of the plastic debris that ended up in the lake came from the nearby homes. The remaining portion was provided by visitors who utilize house boats to visit the lake and Pathiramanal Island. Water contamination in the area was brought on by the massive amount of plastic waste that accumulated around the Pathiramanal Island and accumulated over many years, leaving a layer in the water. The findings highlight the necessity of appropriate waste management and additional investigation into micro-plastic contamination in the lake's surface water.

It is also known from previous studies that Vembanad Lake's water quality is extremely contaminated, particularly in the Pathiramanal region. The sustainability of the island's ecology and the continued existence and health of species depend on the quality of the water. Estuaries are dynamic environments that fluctuate significantly over time and space in terms of their chemical, physical, and biological properties (Ramakrishnan, 2000). The ability of species to successfully deal with changes in salinity, currents, waves, suspended particle matter (SPM), temperature, air exposure, wetland contaminants, and biodiversity is essential to the ecological health of estuaries. The physical characteristics of water are significantly influenced by the depth of a body of water. The depth of the Vembanad Estuary is falling at a rate of 1% annually, and this trend has increased since the Thannermukkam barrier was built, especially the cofferdam that sits in the center of the estuary.

By examining previous studies, the physical properties of the Vembanad backwater, such as its depth, temperature, clarity, and salinity, were investigated in order to gain knowledge of the impacts that human engagement has caused to Pathiramanal Island and Vembanad Lake. The lake's average depth in the island region has dropped to 2.14 ± 1.10 m from 2.52 ± 0.65 m in the 1990s. The greatest depth, which was 9 meters in the 1990s, is currently just 7. Sewerage reclamation and illicit building operations have also significantly altered the lake's depth (Laad, 2016). Climate, geography, solar radiation, and water depth all affect water temperature. Water temperature in the Vembanad Estuary was 27–33°C in the 1990s, but by 2020, it had increased to 30–38.5°C. Transparency is an indicator of relative primary production and pollution levels in the lakes's environment. In 2020, Chithirakayal had the highest level of transparency, while the Nehru Trophy finishing point and Meenappally had the lowest levels. Between February and April, the water column's average clarity was 0.53 ± 0.30 meters. In surface water, salinity levels varied from 2 to 29.5 ppt in 1990 to 0 to 11 ppt in April 2020. The amount of salt in water, or salinity, affects both the physical and chemical processes like flocculation and dissolved oxygen levels, as well as the kinds of species that live in estuaries.

pH is a crucial ecological factor affecting aquatic systems, as inhabitants are adapted to an optimum pH (Khator, 1988). Primary production, respiration, and mineralization processes can alter pH, affecting oxygen and carbon dioxide concentrations. In the Vembanad estuary, a slight acidic to alkaline condition was observed, indicating seawater influence and higher biological activity. Existing research studies revealed the following observations about the chemical features of surface and bottom water in the area, including pH, alkalinity, dissolved oxygen, biological oxygen requirement, and hydrogen sulphide. Surface water pH values ranged from 6.25 to 7.2 in 1990, but have now altered to 6.52 to 7.52 in 2020. In 2020, bottom water had a higher average pH than surface water, ranging from 6.93 ± 0.39 to 7.05 ± 0.33 , compared to 6.99 ± 0.37 to 7.11 ± 0.33 in 1990. In 2020, surface water alkalinity concentrations were between 20 and 100 mg L⁻¹; meanwhile, in 1990, they were between 15 and 90 mg L⁻¹. In 1990, the mean daily oxygen (DO) value of the surface water in the Vembanad estuary ranged from 3.94 to 11.81 mg L⁻¹ (Bhavya et. al., 2016). However, it is presently 2.91–7.87 mg L⁻¹. The concentration of dissolved oxygen (DO) is essential to the health and diversity of aquatic life. Fish deaths, benthic defaunation, and a decline in diversity can result from inadequate DO. Seasons and hypoxia can have an impact on DO levels, which can alter the variety of fish and benthic invertebrates.

The Vembanad Estuary's hydro-chemical composition is also altered, with an increase in ammonia, silicate-silicon, phosphate-phosphorus, and hydrogen sulphide in the bottom water (Sultan. et. al., 2003). The concentration of hydrogen sulphide rose from 0.05 to 2.7. From 6.08 to 9.86, the phosphate-phosphorus concentration rose. Hydrogen sulphide, a toxic compound, can cause acute mortality in aquatic animals at low concentrations. High concentrations were observed in upstream Vembanad backwater, with maximum concentration observed in Punnamada. From 1.72 to 13.64, the silicate-silicon concentration rose. Silicate, an important algal nutrient, is a product of weathering and erosion of rocks on land, transported to the sea. It has no human sources and may limit diatom production at high levels of nitrogen and phosphorus. Increased silicate concentration in Vembanad backwater may be due to discharges from rivers and terrestrial runoff. In 1990, ammonia levels varied from 0 to 7.38 $\mu\text{mol L}^{-1}$; today, they range from 1.78 to 10.53 $\mu\text{mol L}^{-1}$.

Other contaminants include heavy metals, which are particularly dangerous for aquatic systems because they can cause cancer and other harmful effects on living things (Kumar et al., 2014). Different metals can be found in the Vembanad backwater from both natural and human sources. Physical and chemical factors such as temperature, salinity, pH, dissolved oxygen, particle size of the sediment, and availability of nutrients influence the distribution, sequestration, and concentration of heavy metals in aquatic settings (Laluraj et al., 2008). Urbanization and industrialization have raised the concentration of heavy metals in the Vembanad backwater (Selvam et al., 2011); more accumulation was seen in the monsoon season than in the hot season. Heavy metal pollution in Vembanad backwater poses a significant threat to organisms and human consumption.

According to the study's data, the Pathiramanal region of the backwater had an average concentration of heavy metals that was higher than that of other regions, with higher concentrations recorded during the monsoon tourist season. The higher concentrations suggest a greater likelihood of human influence throughout time on the distribution of these metals in the estuary. Moderate pollution for Cu, Cd, Pb, and Zn was also identified by the study. High geo accumulation index values for Cd and Ni were also discovered in the current chemical investigations, indicating significant pollution from these heavy metals. Additionally, the average pollutant load index (PLI) was greater, suggesting that the Pathiramanal area contains contaminated sediments.

The Vembanad backwater included several newly discovered contaminants, including cyclonesiloxane, cycloheptasiloxane, benzyl benzoate, and benzenepropanoic acid, according to the recent study. These substances are common in tourist destinations, particularly in the Pathiramanal region and other populous places, and are important constituents in medications and cosmetics (Greenstone & Hanna, 2014). The biological activity and biodegradation resistance of pharmaceuticals are natural qualities that add to their environmental persistence. Concerns concerning possible risks provided by other drugs with little or no data are raised by the fact that only a tiny percentage of pharmaceuticals in use have environmental risk evaluations accessible.

Can Responsible Tourism lessen these threats?

The beautiful green scenery and many of backwaters in the Alappuzha district have led to considerable tourism developments; in 2018, 2 lakhs domestic and 50 thousand foreign tourists visited the area. Aqua-based tourism is driving infrastructural development, eco-cultural revival, and resource protection as water bodies and marine resources continue to expand. Wetlands and tourism related to wetlands, such as Kerala in India, appeal to a variety of tourist demographics since they provide relaxing cruises and adventurous water sports.

The idea of "responsible tourism" pushes travel agencies to assume accountability for environmentally friendly travel. The 2002 Cape Town Declaration makes the case that ethical tourism reduces adverse effects on the economy, environment, and society; it also benefits local communities economically; it enhances working conditions; it helps preserve the environment and cultural heritage; and it offers visitors pleasurable experiences. Kerala's tourism policy was founded in 2007 with the adoption of Responsible Tourism (RT). Kumarakom, Thekkady, Wayanad, Kovalam, and Bekal were selected by the Kerala government to serve as pilot cities for the concept's implementation at that time. However, the District Tourism Development Authority's lack of attention to responsibility and sustainability is still apparent from the rising pollution levels in Vembanad Lake and Pathiramanal Island.

The RT agenda seeks to decrease undesirable effects on the environment, economy, and society; increase local economic gains; promote host community well-being; and expand industry access and working conditions (Biju & Mathew, 2017). Due to its rapid access to innate resources, highly accomplished labor, encouraging entrepreneurial community, robust local self-government, civil society organizations, plethora of micro-businesses, professionals, academicians, and responsible media, Kerala has become one of India's leading tourism trendsetters. It will make a difference if we employ the potential protections of responsible tourism to check the amount of plastic and bio trash that is being dumped into Vembanad Lake.

8. MAJOR CHALLENGES

Being blessed with attractive natural settings, Pathiramanal Island has all the potential to develop into an international biodiversity spot cum responsible eco-tourism hot spot. But there are some serious challenges also. The first and foremost concern to develop tourism activities at Pathiramanal should be eco-friendly transportation. Most of the domestic tourists prefer rental boats locally available which are petroleum fuel boats that may create water pollution in the lake as the number of visitors increased. If the authorities will ensure and provide public conveyance for the visitors, it will largely reduce the environmental pollution.

The second need is electricity. There is no action for power supply till now even though solar and other non-conventional energy sources are available there. The island is in total darkness during nights and thus visitors are evacuated from the island before the sun set. Moreover, the darkness is usually utilized by the anti-socials, the major threat for the visitors, as there is no security measures or police assistance there. The authorities should take steps to install light inside the walkway on solar power; it will be attractive and beneficial for the visitors.

There is no accommodation facility on the island. Only two toilets are available. During season, when thousands of visitors are at a time, this will create discomfort among the visitors. A watch tower, police Aid post, security room and clock room are the essential requirements, but not provided by the authorities. Multi storied and concrete buildings are not allowed as it is eco sensitive zone, but it is mandatory to provide at least basic amenities for the visitors. Night stay was the prime demand of the foreign as well as domestic travelers, but still no project is designed for the purpose. No seats or chairs are there for relax the visitors. No waste bin or waste control measures are provided yet. As a consequence, the island is filled with plastic carry bags, bottles and other items carried by the travelers. If Kumarakom backwater tourism adheres to the true responsible tourism principles, it can succeed in protecting its natural resources, fostering socioeconomic growth, and bringing back endangered artistic traditions (Kokkranikal & Morrison, 2002). For long-term success, decentralization and environmentally responsible initiatives are essential. It is thought that responsible tourism enhances environmental enhancement and capacity building, necessitating stakeholder consultation and skill development.

The following recommendations are made in an attempt to preserve Pathiramanal Island and Vembanad Lake; these could be implemented through initiatives for sustainable development and responsible tourism. The management of fishery resources, bird conservation, salinity intrusion control, flood control measures through responsible tourism is crucial for the protection of Vembanad ecosystem and Pathiramanal Island. Fishery resources can be managed through ranching endangered species, establishing protected fish sanctuaries, and regulating fishing gear use. Bird conservation should be based on ecological reasons and suitable protected areas. Salinity intrusion control should be studied and the Thannermukkam barrier's water tightness ensured. Flood control measures should be implemented, and houseboats should have separate collection chambers for waste treatment. Mangroves can be replanted in ecologically designated areas. Fifty percent of the catchment area should implement conservation measures related to soil and water. For efficient management, it is advised to regularly monitor and assess hydrological features, water quality indices, and biodiversity components.

9. CONCLUSION

The once-praised ecosystem and biodiversity of the Pathiramanal Islands is currently declining daily because of human meddling. Due to pollution and anthropogenic activity, the Vembanad Lake and its wetlands, which include Pathiramanal Island, are experiencing an environmental disaster. Major effects include avifauna reduction, mangrove vegetation, floods, sedimentation, deterioration of water quality, and lake depth. For conservation and management, an all-encompassing strategy is required, encompassing measures to preserve biodiversity, regulate pollutants, enhance water quality, and implement watershed area treatment. Wetlands, which are vulnerable natural resources, are a popular tourist destination in Kerala because they attract migratory birds, protect flora and fauna, and offer activities such as angling. Pathiramanal Island, a Ramsar Site in Kerala's Alappuzha district, is urgently requires true Responsible Tourism efforts to enhance sustainable resource management and local livelihood activities.

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REFERENCES

1. Ashok Trust for Research in Ecology and Environment. (2009). Vembanad Fish Count - Report of the Participatory Fish Resources Surveys of Vembanad Lake (Kerala) done in 2008 and 2009 by ATREE. India Water Portal. <https://www.indiawaterportal.org/articles/vembanad-fish-count-report-participatory-fish-resources-surveys-vembanad-lake-kerala-done>
2. Bhavya, P. S., Kumar, S., Gupta, G. V. M., Sudharma, K. V., Sudheesh, V., & Dhanya, K. R. (2016). Carbon isotopic composition of suspended particulate matter and dissolved inorganic carbon in the Cochin estuary during post-monsoon. *Current Science*, 110(8), 1539–1543. <http://www.jstor.org/stable/24908111>
3. Biju, S. M., & Mathew, A. (2017). A Connected Future. *ITNOW*, 59(4), 12–15. <https://doi.org/10.1093/itnow/bwx116>
4. B. Sudheer (2015): 'Economic and Cultural Impact of Responsible Tourism Initiative In Kerala-A Case Study of Kumarakom Panchayath', UGC Minor Research Project Report, UGC, New Delhi.
5. Devi. S. (2009). Ecology of mangrove patches in the Vembanad Lake at Panangad, M.F.Sc. Thesis, Kerala Agricultural University, Thrissur.
6. Ganesan, M., Nallathambi, G., & Srinivasalu, S. (2019). Fate and transport of microplastics from water sources. *Current Science*, 117(11), 1879–1885. <https://www.jstor.org/stable/27138574>
7. G, Wall., & A. Mathieson, (2006), *Tourism, Change and Opportunities*, Harlow: Pearson Education Limited
8. Greenstone, M., & Hanna, R. (2014). Environmental Regulations, Air and Water Pollution, and Infant Mortality in India. *The American Economic Review*, 104(10), 3038–3072. <http://www.jstor.org/stable/43495313>
9. James, E., J. (2007). Hydrologic Consideration in the Management of Wetlands of Kerala, *Proceedings of Kerala Environment Congress 2007*, Trivandrum, Kerala.
10. Joseph, P., Nandan, S. B., & Jayachandran, P. R. (2018). New species of *Victoriopisa* Karaman & Barnard, 1979 (Crustacea: Amphipoda: Eriopisidae) from Vembanad backwaters, Southwest coast of India. *Zootaxa*, 4433(1), 69. <https://doi.org/10.11646/zootaxa.4433.1.3>
11. Karlaganis., C and N.C. Narayanan., (2014). Governance Challenges in Linking Environmental Sustainability to Tourism: Where is the House Boat Industry in Kerala ,India Headed? Working Paper No 2013/09
12. Khator, R. (1988). Organizational Response To The Environmental Crisis in India. *The Indian Journal of Political Science*, 49(1), 14–39. <http://www.jstor.org/stable/41855350>
13. Kokkranikal, J., & Morrison, A. (2002). Entrepreneurship and sustainable tourism: The houseboats of Kerala. *Tourism and Hospitality Research*, 4(1), 7–20. <http://www.jstor.org/stable/23743734>



14. Kumar, P. K. D., Gopinath, G., Murali, R. M., & Muraleedharan, K. R. (2014). Geospatial Analysis of Long-Term Morphological Changes in Cochin Estuary, SW Coast of India. *Journal of Coastal Research*, 30(6), 1315–1320. <http://www.jstor.org/stable/43290018>
15. Laad, P. (2016). Physico chemical bacteriological studies of Omkareshwar dam reservoir at river Narmada with special emphasis on human health. *Shodhganga*. http://shodhganga.inflibnet.ac.in:8080/jspui/bitstream/10603/237932/1/01_title%20page.pdf
16. Laluraj, C. M., Gopinath, G., Kumar, P. K. D., & Balachandran, K. K. (2008). Hydrodynamic and Geomorphic Controls on the Morphology of an Island Ecosystem in the Vembanad Lake, West Coast of India. *Journal of Coastal Research*, 24(2B), 145–150. <http://www.jstor.org/stable/30138752>
17. Malamel, J. J., & Sudhikumar, A. V. (2020). An investigation of diversity and bioecology of araneofauna of Pathiramanal Island in Vembanad Lake, a Ramsar site, Kerala, India. *Zoology and Ecology*, 30(2), 126–137. <https://doi.org/10.35513/21658005.2020.2.7>
18. Nair, C. M., Salin, K. R., Joseph, J., Aneesh, B., Geethalakshmi, V., & New, M. B. (2013). Organic rice–prawn farming yields 20 % higher revenues. *Agronomy for Sustainable Development*, 34(3), 569–581. <https://doi.org/10.1007/s13593-013-0188-z>
19. Ramakrishnan Korakandy. (2000). State of the Environment in Kerala: What Price the Development Model? *Economic and Political Weekly*, 35(21/22), 1801–1804. <http://www.jstor.org/stable/4409317>
20. Remani, K., Jayakumar, P., & Jalaja, T. (2010). Environmental Problems and Management Aspects of Vembanad Kol Wetlands in South West Coast of India. [https://neptjournal.com/upload-images/NL-7-7-\(7\)-B-1472com.pdf](https://neptjournal.com/upload-images/NL-7-7-(7)-B-1472com.pdf)
21. Satheeshkumar, P., Manjusha, U., & Pillai, N. G. K. (2011). Conservation of mangrove forest covers in Kochi coast. *Current Science*, 101(11), 1400–1400. <http://www.jstor.org/stable/24080205>
22. Selvam, A. P., Priya, S. L., Banerjee, K., Hariharan, G., Purvaja, R., & Ramesh, R. (2011). Heavy metal assessment using geochemical and statistical tools in the surface sediments of Vembanad Lake, Southwest Coast of India. *Environmental Monitoring and Assessment*, 184(10), 5899–5915. <https://doi.org/10.1007/s10661-011-2389-8>
23. S. Prasanth Narayanan and Lalitha Vijayan(2008): ‘Major threats and needs for the conservation of Kumarakom Heronry of Kerala’, [National Academy Science Letters](#) 31(9):293-296
24. Sultan. B., Jai. C., & Sharma. S. (2003). Physico-Chemical characteristics of North Indian lakes. *J. Aquat. Biol.* 11(1):72-78.
25. Thomas, J. V., Sreedevi, C., & Kurup, B. M. (2006). Variations on the infaunal polychaetes due to bottom trawling along the inshore waters of Kerala (south-west coast of India). <http://nopr.niscair.res.in/bitstream/123456789/1523/1/IJMS%2035%283%29%20249-256.pdf>
26. Zacharias.,S.,Manalel.J.,M.C Jose.,& Salan., A(2008). Backwater Tourism in Kerala: Challenges and Opportunities, Conference of Tourism in India-Challenges Ahead

THE NATURE AND EXTENT OF VIOLENCE AGAINST WOMEN IN THE 19 METROPOLITAN CITIES IN INDIA: AN ASSESSMENT STUDY

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ABSTRACT

Violence against women is a global phenomenon. The rational thinkers of every society are always advocating the execution of human resources, irrespective of gender, to face global competition but they failed to implement it in our multi-dimensional social spheres. It is observed that the power in any form, it may be physical, political, religion, social etc., dominates every society and women arena happen to be the easy ground to exercise that power. In India women empowerment now becomes merely a theoretical concept because no serious actions have taken from any powered lobby to uphold women and provide equal rights and opportunities as men. India women are not only deprived from their human rights but also face cruelty against them and that severely hinders Indian development process. This study is an endeavour to assess the nature and extent of violence against women in Indian metropolitan cities. The study is based on data collected from NCRB on crimes against women in 19 metropolitan cities in India during 2016-2021. This study reveals that violence against women in recent years has reached at an alarming stage in India. Even, metropolitan cities like Delhi, Mumbai, Bengaluru, Hyderabad and Pune become unsafe for women to live and work there. In this regard police and judiciary departments' roles are not at all commendable. Only plausible solution to this problem is to take serious efforts to make necessary social and institutional reforms simultaneously.

KEYWORDS. *Crime; Human Rights; Women Empowerment; Violence.*

1. INTRODUCTION

There is no denying the fact that both men and women are the architects of our human civilization. But, since the inception of human civilization women had remained been deprived of from their rights and privileges throughout the world. Now-a-days, the national and international policy makers are also advocating that women empowerment would be a means to overcome from the clutches of women deprivation and their poverty and therefore the concept of inclusive growth has been emphasized in their development policy formulations. On the other hand, at present human resources appears as the prime factors to maintain or to achieve competitive advantages in the present globalized competitive markets. Therefore, it would never be wise to keep unutilized or underutilized nearly half of any economy's potential human resources. We find that women are not given due opportunities, rather deprived from revealing their virtual potentiality. It is also observed that despite policy makers' efforts to raise the levels of education, gender awareness and stringent pro-women laws, women are yet to be considered as equal to men.

Violence against women happens to be a common phenomenon throughout the world and in true sense it is ultimately violation of human rights. United Nations (1993) identify violence on women as the materialization of unequal power relationship between men and women (UN, 1993). Although it is an age-old problem but it comes to the spotlight only two or three decades earlier in India. Violence generate both physical (Plichta & Abraham, 1996; Campbell et al., 2002) as well as psychological (Parker & Lee, 2002a; Matud, 2005) distress among women. Such distresses seriously challenge their productivity and autonomy which is detrimental to development (Agarwal, 1997). In recent years, gender-based violence has reached at an alarming stage in India. The irony of the fact is that woman's probability of being abused would be higher if she is attached with any job and that defy women empowerment. In India, although the National Crime Records Bureau (NCRB) provides data on crimes against women in India, but in reality, the actual number of violence against women is higher than that of the reported figures because the victims and her families hesitate to report crimes against them due to some social stigma as well as the reluctance from the part of some of the police officials to register complaints. Again, sub-standard investigations turn to low conviction rates and that also restrain the victims to lodge complaint to police. Therefore, the common impression is that there is little benefit in reporting the crime. Government of India has implemented specific legislative measures to reduce such social crimes, but unfortunately violence against women has been continuing to exist in our society.

In Indian the patriarchal form of society embedded by its cultural norms and conservative social structure is responsible for violence against women. Here in India, interpersonal relationship as well as gender relationship is administered by the cultural values and religious beliefs. As a result, there had been created separate codes of conducts for men and women even with respect to their daily life activities (Roy, 2003). The different codes of conduct were introduced by Manu, a sage of the later Vedic period, where women are assigned to serve men and the family. This masculine biased code of conduct leads to indulgence of violence on women to keep them under control (Sugarman & Frankel, 1996; Yick, & Agbayani-Siewert, 1997). In patrilineal families, gender socialization trains children with different sexes to be socialized into their gender roles (Giddens, 1993). Hence, women's education, their social and economic hierarchical background etc. never become factors towards reducing violence.

It therefore appears that the inherent restrictive socio-religion norms come on the way to limit women's choices and access to opportunities. It is being observed that in the labor market women get wage less than that of men for similar work and eventually they are more likely to be in poverty even when they work. National and international policy makers advocated women empowerment as a mean to overcome this situation and in their development policy formulation the concept of inclusive growth has been emphasized. It is also observed that economic globalization significantly enhanced job opportunities for both male and female in various sectors in India. This initiates women to join the job market in a significant number in India, defying social norms. On the other side, it is revealed in the NCRB statistics that in recent year violence against women has reached at an alarming state in India. However, it is observed s that women access to job market in significantly increased in number which indicates enhancement of women's financial empowerment, freedom of movement etc. On the other, the alarming state of violence against women in India is undermining the revealed status of women empowerment. The crimes against women have continuously halting women from getting out of their homes and joining the work force. Hence, the interplay of these positive and negative forces in our socio-economic arena twined together created a very complex socio-economic environment throughout India. Keeping all these factors in mind, this study is an endeavor to assess the nature and extent of crimes against women in India, especially in the 19 metropolitan cities and try to provide some plausible remedial measures for the sake of achieving our national goals.

2. LITERATURE REVIEW

Despite adoption of several legislative measures specific to eradicate crime against women by the Government of India but unfortunately in our society the incidence of crime against women has been showing an increasing trend over the

last more than three decades. However, let us begin our search to find out the basic theories on Roots of Violence against women provided by scholars. Some of the fundamental theories on violence against women are provided below.

- ***Cultural norms and conservative social structure***

It appears that the patriarchal form of society embedded by its cultural norms and conservative social structure is responsible for violence against women.

- ***Cultural values and Religious beliefs***

Manu, the sage of the later Vedic period, announced different codes of conducts for men and women where women are assigned to serve men and the family. Since then, the cultural values and religious beliefs dictate gender relationship in accordance with the specified respective codes of conduct for men and women, even in the daily life activities. As a result, the masculine biased code of conduct had been established and that leads to indulgence of violence on women to keep them under control.

- ***Emergence of Private Property***

Marxian feminist theory explained that the patriarchal family concept was linked with the development of agriculture and the emergence of private property. To ensure the proper heir to this acquired property, a patrilineal line of inheritance was established. For implementing this line of inheritance, control on women became inevitable and eventually they were treated as property. Women became an instrument for producing children and serving the family as well as a source of cheap labor for generating surplus of production.

- ***Status Inconsistency Theory***

According to this theory, family is a power system with variation in the distribution of resources among its members. Traditionally power and right to earn for the family are assigned to man; if any threat arises to this status, which is inconsistent to prevailing social norms insists him to start violence to protect his position. Thus, women's any endeavor for economic independence is regarded as a challenge to the men's customary authority which forces men to respond (Hornung, McCullough & Sugimoto, 1981; Macmillan & Gartner, 1999; McCloskey, 1996; Yick, 2001).

- ***Backlash Theory (Based on the notion of anti-feminism)***

Backlash theory is based on the notion of anti-feminism which denies women's aspirations, achievements and demand for equality (Faludi, 1991) and explains the reasons of violence on women particularly economically independent women.

- ***Exchange Theory***

The exchange theory pinpoints that male generally uses money and violence as two controlling devices (Molm, 1990). For unemployed women, men use their money power to keep them under grip. However, for employed women, money power appears to be less effective, which provoke men to exercise their muscle power as an alternative device.

- ***Social Bond Theory***

Social bond theory describes the role of social norms and social organizations behind socializing individuals. For example, Indian women cannot cease violence on them by ending their marriage relation with men because Indian social norms are against divorce/separation. and Indian girls since their childhood learned that any sort of negligence of duty or disobedience towards family will inflict punishment, which they should bear without protest. As a result, women are compelled to bear cruelty against them silently (Chaudhary, 1988).

It is observed that domestic violence is a common phenomenon in Indian societies. The male dominated conservative social structure encourages and condones violence on women. In patrilineal families, children's socialization is made in accordance with their gender specific roles (Giddens, 1993). Because of the fear that economic independence may

help women to escape from family control and therefore Indian women are discouraged to opt for job and are guided by the social structure. As a result, only 40 percent women are found in the job market and surprisingly they are subject to more domestic violence than jobless women (Third National Family Health Survey, 2005-06). RTI studies shows that employed women have more than 80 per cent higher chance of being abused by their husbands than that of unemployed women and this incidence increases further if husbands of those women lose job or face problems at work place (The Hindu, 2009). This observation contradicts the hypothesis that job helps women to achieve some autonomy, which in turn will help to reduce violence on them (Tauchen, Witte & Long, 1991; Watts, 2006; Kjersti, Bente & Valborg, 2009). Some probable explanations of these are found in the status inconsistency theory, backlash theory and exchange theory.

3. OBJECTIVES OF THE STUDY

The study is mainly concerned with violence against women in the 19 major metropolitan cities in India. The objectives of the study are:

- To find out the nature and extent of violence against women in the metropolitan cities in India.
- To identify the lacuna in our police and judiciary system towards minimizing such social crimes against women.
- To suggest some plausible effective means to get rid of crimes against women.

4. DATA AND METHODOLOGY

This study is based on secondary data. The data have been collected from National Crime Record Bureau (NCRB), Ministry of Home Affairs; Government of India from 2016 to 2021. This study is mainly focused on the crimes against women in the 19 major metropolitan cities (having more than 2 million populations) in India. For the sake of simplicity simple statistical analyses, like mean, percentage distribution, rank distribution etc. have been estimated and are presented in the form of statistical tables and graphs.

5. ANALYSIS AND DISCUSSION

During the past few decades' violence against women has become rampant in India. This phenomenon is not only a violation of human rights but also it weakens our efforts of national development. Therefore, it becomes pertinent to address this issue and at the same time proper necessary remedial measures are necessarily taken to curve this situation. This study tries to assess the nature and extent of violence against women in the 19 metropolitan cities with more than 2 million populations in India over the period from 2016 to 2021. The data are collected from the published reports of NCRB. Although it is known that the NCRB collects crime data as per supplied by the governments of respective states and union territories. The actual scenario might be graver than what is depicted in this study.

At the outset it would be worthwhile to make a glim of the overall situation of crimes against women in India during 2016-2021. It is clearly observed that the trend of growth of crimes against women had increased significantly every year from 2016 to 2019 then a decrease in 2020, i.e. during the Covid period and again it starts a rising trend in 2021 (see figure-1). This implies that the overall trend growth of crimes against women in India appears as alarming.

This study is mainly concerned with the nature and extent of crimes against women in the 19 metropolitan cities with more than 2 million populations. These 19 metropolitan cities are distributed over 12 states (Bihar, Delhi, Gujarat, Karnataka, Kerala, Madhya Pradesh, Rajasthan, Tamil Nadu, Telangana, Uttar Pradesh and West Bengal) of India. Before going into the assessment of city-wise nature and extent of crimes against women, it would be wise to see the scenario of crimes against women in the above 12 states.

It appears (see table-1) the average number of women victims per thousand female populations in the respective states is highest in Delhi (146), followed by Telangana (96), Rajasthan (89), Madhya Pradesh

(71), West Bengal (69). In this regard the least number of victims are recorded in Gujarat (26). It also appeared that the number of women victims per thousand female populations decreased during the covid period in 2020 and sharply increased in 2021 which is happens to be the all India picture. One interesting finding is that the decrease in number of victims from 2019 to 2020 is much less than the number increases from 2020 to 2021 in all the concerned states. The ranks of the states in terms of number of women victims per thousand respective female populations are maintained in each of the years from 2016 to 2021.

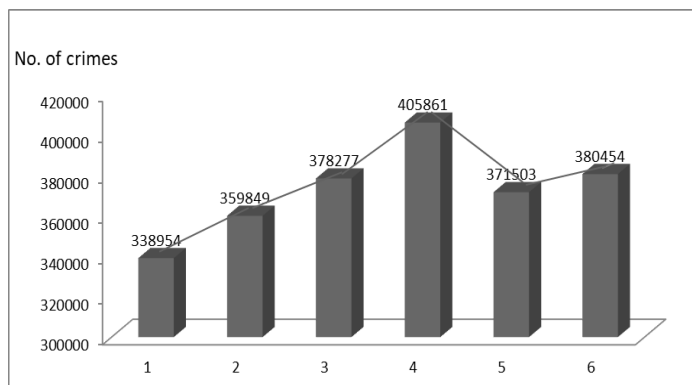


Fig 1. Number of Crimes in India against Women during 2016-2021

Now, it is observed that with regard to the average crimes against women in the metropolitan cities as percentage of the respective state total crimes against women, Delhi top the rank (93%), followed by Bengaluru (24%), Ahmedabad (17%), Mumbai (16%), Hyderabad (14%) and Chennai (11%). Delhi falls under the union territory, but now-a-days it is also considered as a state. Delhi is the capital city and it has no or insignificant rural parts therefore its percentage share appears so high. In this respect, the percentage share of crimes against women to its state's total crimes against women in Ghaziabad metropolitan city is least (1.5%) (see table-2).

Here, one interesting observation is that although in Ghaziabad metropolitan city the share of crimes against women as percentage state's (Telangana) total crimes against women is least but Telangana is state where average number of women victims per thousand female populations is the second highest (see table-1). This means crimes against women have significantly happened in other cities and in the rural areas as well.

Again, if compare the percentage share of crimes against women to the total crimes of the 19 metropolitan cities over the period between 2016-2021, Delhi would be obviously tops the ranks (ranges between 27.3% to 32.2%) and the reason behind this has been explained in the earlier section. Next to Delhi comes Mumbai (ranges between 12.3% to 14.4%) and that followed by Bengaluru (ranges between to 7.2% to 8.7%), Hyderabad (ranges between to 5.5% to 7%) and Pune (ranges between 4.5% to 7.5%) (see table-3).

Table 1. Number of Women Victims per Thousand Female Population of the respective States during 2016-21

State/UT	No. of Victims per thousand Female Population in State						Six Years Average (2016-2021)
	Years						
	2016	2017	2018	2019	2020	2021	
Bihar	25 (54703)	26.5 (55577)	29.9 (56450)	32.4 (57324)	26.4 (58197)	30.4 (59071)	28.4 (56887)
Delhi	176.0 (8697)	147.3 (8879)	150.5 (9061)	144.9 (9244)	107.1 (9426)	148.6 (9609)	145.7 (9153)

Gujarat	27.5 (31,087)	25.8 (31,507)	26.1 (31,927)	27.2 (32,347)	24.5 (32,768)	22.1 (33,188)	25.5 (32137)
Karnataka	44.6 (31,661)	44.1 (31,916)	42.0 (32,170)	42.6 (32,425)	38.8 (32,679)	43.9 (32,934)	42.7 (32298)
Kerala	55.8 (17,984)	61.2 (18,077)	57.6 (18,169)	62.8 (18,262)	55.2 (18,354)	73.4 (18,447)	61 (18216)
Madhya Pradesh	69.9 (38,069)	77.1 (38,637)	73.8 (39,204)	69.3 (39,772)	63.6 (40,339)	75 (40,907)	71.5 (39488)
Maharashtra	55.0 (57,078)	55.5 (57,609)	61.1 (58,140)	63.3 (58,672)	54 (59,203)	66.2 (59,735)	59.2 (58406)
Rajasthan	76.4 (35,890)	71.4 (36,414)	75.4 (36,938)	111 (37,462)	90.9 (37,985)	105.8 (38,509)	88.5 (37200)
Tamil Nadu	12.0 (37,294)	14.4 (37,482)	15.5 (37,671)	15.7 (37,860)	17.4 (38,049)	22.2 (38,237)	16.2 (37766)
Telangana	84.9 (18,116)	96.0 (18,242)	87.3 (18,368)	99.5 (18,495)	95.5 (18,621)	111.3 (18,747)	95.8 (18432)
Uttar Pradesh	47.7 (1,03,278)	53.5 (1,04,735)	56 (1,06,192)	55.6 (1,07,649)	45.3 (1,09,106)	50.7 (1,10,563)	51.5 (106921)
West Bengal	70.0 (46423)	66.3 (46744)	64.6 (47066)	64.1 (47387)	76.4 (47708)	74.7 (48029)	69.4 (47226)

Source: National Crime Record Bureau from 2016 to 2021, Ministry of Home Affairs, Govt. of India.

- Figures in the parentheses indicate state wise female population (in '000)
- Authors own calculation

It is observed that crimes against women are multi-dimensional in nature, like 'Murder with rape or Gang rape or rape', 'Dowry deaths', 'Acid attack', 'Cruelty by husband or his relatives', 'Kidnapping and Abduction of women', 'Importation of girls from foreign country', 'Human trafficking', 'Selling of minor girls', 'Assault on women with intent to outrage her modesty' etc.

Table 2. Share of Metropolitan City as Percentage of State Total Crimes against Women

State/UT	Metropolitan City	Crimes against women in the Metropolitan Cities as percentage of State Total Crime Against Women						Six Years Average 2016-21
		Years						
		2016	2017	2018	2019	2020	2021	
Bihar	Patna	9.6 (13400)	5.9 (14711)	5.7 (16920)	5.3 (18587)	3.2 (15359)	2.7 (17950)	5.4 (16155)
Delhi	Delhi City	90.2 (15310)	88.3 (13076)	86.0 (13640)	96.3 (13395)	96.9 (10093)	97.9 (14277)	92.6 (13299)
Gujarat	Ahmedabad	13.2 (8532)	17.3 (8133)	17.0 (8329)	18.6 (8799)	19.0 (8028)	21.1 (7348)	17.7 (8195)
	Surat	6.6 (8532)	6.9 (8133)	8.5 (8329)	11.9 (8799)	7.9 (8028)	8.5 (7348)	8.4 (8195)
Karnataka	Bengaluru	24.1 (14131)	25.3 (14078)	25.4 (13514)	25.2 (13828)	21.5 (12680)	21.6 (14468)	23.9 (13783)
Kerala	Kochi	3.9 (10034)	4.8 (11057)	5.1 (10461)	4.3 (11462)	4.0 (10139)	3.9 (13539)	4.3 (11115)
	Kozhikode	3.5 (10034)	3.1 (11057)	3.3 (10461)	4.1 (11462)	3.9 (10139)	4.7 (13539)	3.8 (11115)
Madhya Pradesh	Indore	4.0 (26604)	4.5 (29788)	5.5 (28942)	6.4 (27560)	5.2 (25640)	5.8 (30673)	5.2 (28201)

Maharashtra	Mumbai	16.3 (31388)	17.1 (31979)	17.1 (35497)	17.6 (37144)	14.3 (31954)	14.0 (39526)	16.1 (34581)
	Nagpur	4.4 (31388)	3.6 (31979)	3.1 (35497)	3.1 (37144)	2.9 (31954)	2.9 (39526)	3.3 (34581)
	Pune	6.8 (31388)	6.4 (31979)	4.2 (35497)	3.7 (37144)	3.3 (31954)	4.1 (39526)	4.8 (34581)
Rajasthan	Jaipur	7.6 (27422)	7.1 (25993)	7.3 (27866)	8.2 (41550)	6.9 (34535)	6.9 (40738)	7.3 (33017)
Tamil Nadu	Chennai	12.2 (4463)	11.9 (5397)	13.1 (5822)	12.3 (5934)	8.7 (6630)	10.3 (8501)	11.4 (6125)
	Coimbatore	2.3 (4463)	1.4 (5397)	1.8 (5822)	1.4 (5934)	1.5 (6630)	2.2 (8501)	1.8 (6125)
Telangana	Hyderabad	15.7 (15374)	13.0 (17521)	14.6 (16027)	15.0 (18394)	13.4 (17791)	14.6 (20865)	14.4 (17662)
Uttar Pradesh	Ghaziabad	2.1 (49262)	2.1 (56011)	1.9 (59445)	1.3 (59853)	0.7 (49385)	1.1 (56083)	1.5 (55007)
	Kanpur	2.1 (49262)	2.8 (56011)	2.6 (59445)	2.2 (59853)	2.1 (49385)	1.6 (56083)	2.2 (55007)
	Lucknow	4.5 (49262)	4.4 (56011)	4.6 (59445)	4.1 (59853)	5.3 (49385)	3.9 (56083)	4.5 (55007)
West Bengal	Kolkata	5.2 (32513)	6.4 (30992)	7.2 (30394)	7.2 (30394)	5.5 (36439)	5.0 (35884)	6.1 (32769)

Source: National Crime Record Bureau from 2016 to 2021, Ministry of Home Affairs, Govt. of India.

- Figures in the parentheses indicate respective state total crimes against women.
- Authors own calculation

Table 3. Crimes against Women in the Metropolitan Cities over the period from 2016 to 2021

State/UT	Metropolitan City	Years					
		2016	2017	2018	2019	2020	2021
Bihar	Patna	1284 (3.1)	870 (2.1)	956 (2.3)	981 (2.2)	495 (1.4)	487 (1.1)
Delhi	Delhi City	13803 (33.1)	11542 (28.3)	11724 (27.8)	12902 (28.4)	9782 (27.7)	13982 (32.2)
Gujarat	Ahmedabad	1126 (2.7)	1405 (3.4)	1416 (3.4)	1633 (3.6)	1524 (4.3)	1554 (3.6)
	Surat	565 (1.4)	559 (1.4)	712 (1.7)	1015 (2.2)	633 (1.8)	622 (1.4)
Karnataka	Bangaluru	3412 (8.2)	3565 (8.7)	3427 (8.1)	3486 (7.7)	2730 (7.7)	3127 (7.2)
Kerala	Kochi	392 (0.9)	535 (1.3)	537 (1.3)	492 (1.1)	403 (1.1)	531 (1.2)
	Kozhikode	352 (0.8)	347 (0.8)	349 (0.8)	473 (1.0)	394 (1.1)	632 (1.5)
Madhya Pradesh	Indore	1055 (2.5)	1349 (3.3)	1593 (3.8)	1755 (3.9)	1346 (3.8)	1794 (4.1)
Maharashtra	Mumbai	5128 (12.3)	5453 (13.4)	6058 (14.4)	6519 (14.3)	4583 (13.0)	5543 (12.8)
	Nagpur	1379 (3.3)	1152 (2.8)	1083 (2.6)	1144 (2.5)	920 (2.6)	1156 (2.7)

	Pune	2131 (5.1)	2032 (5.0)	1481 (3.5)	1390 (3.1)	1055 (3.0)	1616 (3.7)
Rajasthan	Jaipur	2090 (5.0)	1857 (4.5)	2030 (4.8)	3417 (7.5)	2369 (6.7)	2827 (6.5)
Tamil Nadu	Chennai	544 (1.3)	642 (1.6)	761 (1.8)	729 (1.6)	576 (1.6)	874 (2.0)
	Coimbatore	102 (0.2)	76 (0.2)	107 (0.3)	85 (0.2)	97 (0.3)	190 (0.4)
Telangana	Hyderabad	2419 (5.8)	2272 (5.6)	2332 (5.5)	2755 (6.1)	2390 (6.8)	3050 (7.0)
Uttar Pradesh	Ghaziabad	1031 (2.5)	1166 (2.9)	1128 (2.7)	793 (1.7)	341 (1.0)	591 (1.4)
	Kanpur	1050 (2.5)	1574 (3.9)	1574 (3.7)	1315 (2.9)	1056 (3.0)	894 (2.1)
	Lucknow	2205 (5.3)	2468 (6.0)	2736 (6.5)	2425 (5.3)	2636 (7.5)	2161 (5.0)
West Bengal	Kolkata	1693 (4.1)	1975 (4.8)	2176 (5.2)	2176 (4.8)	2001 (5.7)	1783 (4.1)
City Total		41761 (100.00)	40839 (100.00)	42180 (100.00)	45485 (100.00)	35331 (100.00)	43414 (100.00)

Source: National Crime Record Bureau from 2016 to 2021, Ministry of Home Affairs, Govt. of India.

Note: As per data provided by the states; * Figures in the parenthesis indicate percentage of city total

However, this study mainly concentrates with five major crimes heads which are frequently occurred against women and these incidents are ‘Rape’, ‘Dowry Death’, ‘Cruelty by Husband or his relatives’, ‘Kidnaping and Abduction’ and ‘Assault on Women with intent to Outrage her Modesty’.

Table 4. Number of Crimes against Women during 2016-2021 by Five Major Crime Heads

Crime Head	Year	Total Number of Victims In India	
		In 19 Metropolitan cities	All India
Rape	2016	4957 (12.7)	39068
	2017	2848 (8.5)	33658
	2018	2787 (8.2)	33977
	2019	3314 (10.3)	32260
	2020	2537 (9.0)	28153
	2021	3217 (10.1)	31878
	Average per year (rounded)	3277 (10)	33166
Dowry Death	2016	506 (6.6)	7628
	2017	483 (6.2)	7838
	2018	416 (5.7)	7277
	2019	387 (5.4)	7162
	2020	358 (5.1)	7045
	2021	378 (5.7)	6795
	Average per year (rounded)	421 (6)	7291
Cruelty by Husband or his Relatives	2016	12222 (11.1)	110434
	2017	11729 (10.9)	107458
	2018	11956 (11.5)	104165

	2019	14211 (11.2)	126575
	2020	10733 (9.6)	112292
	2021	14345 (10.4)	137956
	Average per year (rounded)	12533 (11)	116480
Kidnapping and Abduction	2016	9722 (14.6)	66544
	2017	8859 (8.8)	100555
	2018	9174 (8.3)	110410
	2019	8970 (8.3)	108025
	2020	6801 (7.7)	88590
	2021	8829 (11.6)	76263
	Average per year (rounded)	8726 (11)	91731
Assault on Women with Intent to Outrage her Modesty	2016	10535 (12.3)	85332
	2017	9118 (10.4)	87965
	2018	9032 (10.0)	90051
	2019	9263 (10.4)	89371
	2020	6984 (8.0)	87018
	2021	7680 (8.1)	90675
	Average per year (rounded)	8769 (10)	88402

Source: National Crime Record Bureau from 2016 to 2021, Ministry of Home Affairs, Govt. of India.

Note: As per data provided by the states; * Figures in the parenthesis indicate as percentage of all India total/average

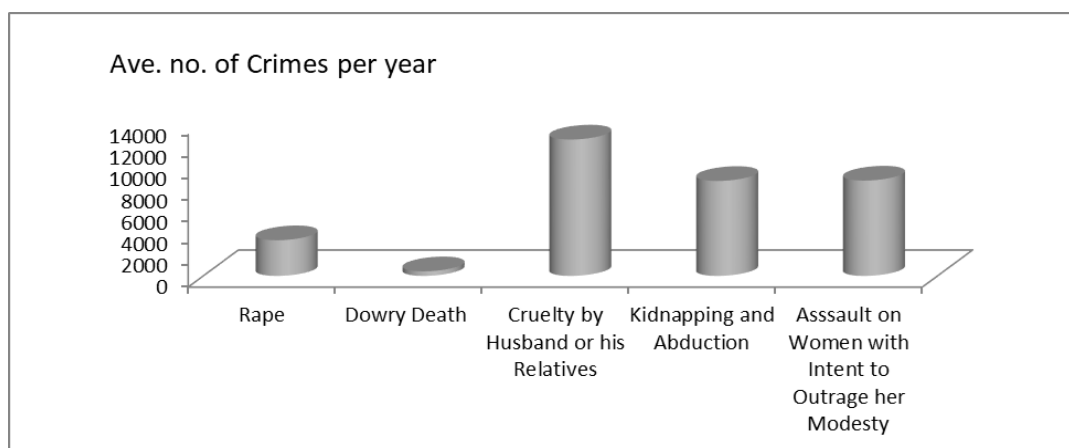


Fig.2 Average number of Crimes per year in the Metropolitan Cities by Crime Heads

Except 'Dowry Death' the average per year crimes against women in the 19 metropolitan cities under the four other crimes head is very significant. In the 19 metropolitan cities the average per year incidents of 'Rape' cases are found to be 3277 (10% of all India average) during 2016-2021. Average number of cases under the head 'Cruelty by husband or his Relatives' is found to be 12533 (11% of all India average); average cases under the head 'Kidnapping and Abduction' is 8726 (11% of all India average) and average cases under the head 'Assault on women with intent to outrage her modesty' is 8769 (10% of all India average). On the other hand, average cases under the head 'Dowry Death' is 421 (6% of all India average) (see table-4). Here, it is observed that the incidents of 'Cruelty by husband or his Relatives' is the highest. It is a clear case of domination of women in the household sector and that domestic violence becomes very common in our society irrespective of economic and social classes. The entire scenario is clearly depicted in Figure-2.

From the above discussion women are not given equal rights and opportunities to live with freedom and liberty as men. They are dominated by all kinds of power lobby. That is in practice, women are deprived opportunities and as a result, they are restrained from revealing their virtual potentiality. Despite sincere efforts to intensify levels of education, gender awareness and stringent pro-women laws, there is still a perception that women are less potential than that of men. To overcome this situation, national and international thinkers introduced the concept of women empowerment which ultimate goals are women's freedom of movement, financial independence and participation in the decision making.

Again, it becomes a matter of great concern that according to National Family Health Survey (NFHS) reports women are becoming more empowered over years, on the other hand, the National Crime Record Bureau reports revealed that crimes against women is becoming very critical and alarming. Thus, it becomes a paradox in itself. Government of India and the local administrations have introduced very stringent pro-female laws to protect women from the violence against them. But our police and judiciary departments in the 19 metropolitan cities are failed to show serious effective action towards protecting women from crimes against them.

Table 5. Status-quo of Police and Court Disposal Crimes against Women in the Metropolitan Cities

Metropolitan city	Police disposal crimes against women in metropolitan city						Court disposal crimes against women in metropolitan city			
	Total cases for investigation		Charge sheeting rate		Pendency percentage		Conviction rate		Pendency rate	
	2016	2021	2016	2021	2016	2021	2016	2021	2016	2021
Ahmedabad	1380	1837	91.9	94.4	18.3	16.1	2.5	2.3	96.2	96.7
Bangaluru	4890	4183	72.1	73.1	44.2	20.8	3.5	3.0	90.3	93.8
Chennai	1585	3145	84.8	95.1	70.2	86.3	36.1	22.7	76.8	91.4
Coimbatore	138	225	95.6	95.4	17.4	61.3	16.7	30.8	74.6	94.8
Delhi	31930	29353	64.6	71.1	61.4	54.2	29.5	38.4	91.8	98.3
Ghaziabad	1334	594	55.5	78.5	22.6	27.9	50.8	15.8	92.2	95.0
Hyderabad	4072	4699	73.3	71.3	33.3	35.5	7.8	15.3	86.2	91.1
Indore	1296	2226	81.9	74.7	20.1	15.8	28.8	41.3	73.0	91.2
Jaipur	2563	3741	45.9	55.1	16.0	18.2	14.1	21.2	96.0	95.0
Kanpur	1495	1559	67.1	78.3	28.1	25.3	53.6	53.8	87.5	89.4
Kochi	487	724	93.2	91.8	18.7	30.5	25.6	10.9	94.4	97.4
Kolkata	2446	4032	84.1	94.1	41.0	41.1	0.0	100.0	98.2	99.9
Kozhikode	565	978	93.4	93.2	38.8	48.9	37.1	7.8	88.2	89.2
Lucknow	2855	3147	53.3	71.3	27.3	26.4	48.4	-	95.3	100.0
Mumbai	10458	17180	80.9	82.9	60.9	73.6	27.5	26.2	94.1	96.7
Nagpur	2095	1627	78.7	74.5	29.8	32.0	8.2	10.8	96.0	97.8
Patna	3494	1071	79.9	93.1	16.7	42.8	10.2	20.0	93.9	99.9
Pune	3187	2709	74.8	77.0	35.4	24.8	9.2	19.6	95.8	98.7
Surat	604	682	81.7	91.6	4.6	8.8	0.0	0.0	100.0	100.0
Total	76874	83712	70.8	75.7	47.8	48.6	22.6	23.2	92.8	96.9

Source: National Crime Record Bureau from 2016 to 2021, Ministry of Home Affairs, Govt. of India.

Overall, in the 19 metropolitan cities the charge sheeting rate of police disposal cases is 75.7 and pendency percentage of police disposal cases is 47.8. This implies that a significant number of cases is pending in the police department due to unfinished investigation or otherwise. The condition of court disposal crimes against women in the metropolitan cities is worse. The pendency rate of court disposal crimes against women is above 90 percent in all the 19 metropolitan cities (see table-5). If prompt and proper actions are not warranted by the police and judicial departments against the criminals those committed crimes against women, the dominating tendency of the male by an end and crimes against women will continue to persist in India.

6. CONCLUDING REMARKS

This study tries to assess the nature and extent of crimes against women in 19 metropolitan cities in India. Over decades' government of India had tried to reduce violence, especially against women, by adopting many legislative measures but this particular social crime against women has been continued to increase over time in our society. The highest incident of violence against women India is observed in the household sector. It is also observed that the probability of being victim of violence increases if the women are in jobs. However, the actual number of violence against women is higher than that of the reported figures because the victims and her families hesitate to report crimes against them due to some social stigma as well as the reluctance of the police officials to register complaints. Sometimes sub-standard investigations turn to low conviction rates and that also restrain the victims from lodge complain to police.

According to NFHS study the women's empowerment at the household has registered at a commendable level. But, according to NCRB reports crimes against women also reaches at an alarming stage and the highest number of crimes are registered at the household level – a paradox. Therefore, these positive and negative factors become counterproductive and detrimental towards achieving faster economic and social goals.

The study acclaims that the crimes against women should be reduced significantly from both human rights and socio-economic point of view. This study also suggests some plausible and effective measures to curve such violence against women. These are (i) proper basic education and extended form of social awareness to propagate the idea that women are complementary to men and they also are the key human resources for the overall enhancement of the people's well-being and thus to build a vibrant nation and (ii) administrations, especially the police and the enforcement of law departments, should take speedy actions against the criminals by giving them proper and strong punishment to restrains others to commit crimes against women.

REFERENCES

1. Agarwal, B. (1997). Bargaining and gender relations: Within and beyond the household. *FeministEconomics*, 3(1), 1-51.
2. Campbell, J., Jones, A. S., Dienemann, J., Kub, J., Schollenberger, J., O'Campo, P., Gielen, A.C., &Wynne, C. (2002). Intimate partner violence and physical health consequences. *Archives of internal medicine*, 16(10), 1157-1163.
3. Chaudhary, J.N. (1988). *Divorce in Indian society: A sociological study of marriage disruption and role adjustment*. Printwell Publishers, Jaipur.
4. Faludi, S. (1991). *Backlash: The undeclared war against American women*. New York: Doubleday.
5. Giddens, Anthony (1993). *Sociology*. Cambridge: Polity Press.
6. Hornung, C. A., McCullough, B.C., & Sugimoto, T. (1981). Status relationships in marriage:Risk factors in spouse abuse. *Journal of Marriage and the Family*,43, 675-692.
7. Kjersti, A., Bente, E. M., &Valborg, B. (2009). Employment, experiences of intimate partner violence, and health related quality of life. *Journal of Psychology and Counseling*, 1(4), 060-063.
8. McClosky, L.A. (1996). Socioeconomic and coercive power within family. *Gender & Society*, 10(4), 449-463.
9. Macmillan, R. & Gartner, R. (1999). When she brings home the bacon: Labour-force partiipation and the risk of spousal violence against women. *Journal of Marriage and the Family*, 61(4), 947-958).
10. Matud, M. P. (2005). The psychological impact of domestic violence on Spanish women. *Journal of applied social psychology*, 35(11), 2310-2322.
11. Molm, L. (1990). Structure, action and outcomes:The dynamics of power in social exchange. *American sociological review*, 55, 427-47.
12. Parker, G., & Lee, C. (2002a), Violence and abuse: An assessment of mid-aged Australian women's experiences. *Australian psychologist*, 37(2), 142-148.
13. Plichta, S.B., & Abraham, C. (1996). Violence and gynecologic health in women < 50 years old. *American journal of obstetrics and gynecology*, 174(3), 903-907.



14. Roy, A. (2003). *Violence against Women*. Rajat Publication, New Delhi, India.
15. Sugarman, D. B., & Frankel, S. L. (1996). Patriarchal ideology and wife-assault: A meta-analytic review. *Journal of Family Violence*, 11, 13-40.
16. The Hindu (2009). Working women face more domestic violence in India: Study, October 29.
17. Third National Family Health Survey (2005-06). International Institute for Population Sciences (IIPS). Ministry of Health and Family Welfare, Government of India.
18. Tauchen, H.V., Witte, A.D. & Long, S.K.(1991). Domestic violence: A non-random affair. *International Economic Review*, 32(2), 491-511.
19. United Nations (1993). "Declaration on the Elimination of Violence against Women", General Assembly resolution 48/104 of 20 December 1993.
20. Watts. C. (2006). *Contested development? Intimate partner violence and women's employment in urban and rural Tanzania*. Gender Violence and Health Centre, Retrieved from genderviolence.lshtm.ac.uk/files/2009/.../GVHC-Project-Portfolio.pdf.
21. Yick.G. A. & Ahbayani-Siewert. P. (1997). Perceptions of domestic violence in a Chinese American community. *Journal of Interpersonal Violence*,12, 832-846.
23. Yick, A. G. (2001). Feminist theory and status inconsistency theory: Application to domestic violence in Chinese immigrant families. *Violence against Women*, 7, 545-562.

HEALTHY CROP IDENTIFICATION THROUGH PLANT IMAGE CLASSIFICATION USING CNN MODELS – A COMPARATIVE STUDY

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ABSTRACT

Crop diseases present a significant challenge to food security and agricultural productivity worldwide. Timely and accurate detection and diagnosis of these diseases are essential for effective disease management and crop protection. The present research work focuses on utilizing machine learning (ML) models, specifically Convolutional Neural Networks (CNNs) like VGG-16, VGG-19, GoogLeNet, and AlexNet, to classify images of crop leaves into healthy or diseased categories. The study employs a comprehensive dataset comprising of about 21,000 samples of crop leaf images from diverse plant species and disease types, sourced from Kaggle. The research has also put forward a comparative analysis of different CNN models to showcase and demonstrate the feasibility and effectiveness of using image classification methods for crop disease recognition. By leveraging advanced technologies such as ML and CNNs, this work contributes to enhancing disease detection accuracy, optimizing disease management strategies, and ultimately bolstering global food security and sustainable agricultural productivity.

KEYWORDS. *Convolutional Neural Network; K-Nearest Neighbor; Hyperparameter; Confusion Matrix; Training loss; Validation loss; Callbacks*

1. INTRODUCTION

Crops are not only essential for sustaining life on Earth but also play a crucial role in maintaining ecological balance, supporting biodiversity, and serving as a vital resource for human survival. However, the health and productivity of plants are constantly threatened by a myriad of diseases caused by pathogens, environmental factors, and other stressors. These diseases can lead to significant losses in crop yields, affecting food security, economic stability, and environmental sustainability.

Detecting and diagnosing plant diseases accurately and promptly is paramount for effective disease management and crop protection. Traditional methods of disease identification, such as visual inspection by farmers or laboratory testing, have limitations in terms of scalability, accuracy, and speed. This underscores the urgent need for innovative solutions that can revolutionize the way plant diseases are detected and managed.

Machine learning (ML) has emerged as a powerful tool in the field of agriculture, offering new possibilities for automating tasks that were once reliant on human expertise. ML models, particularly Convolutional Neural Networks (CNNs) [13] have shown great promise in image analysis tasks, including image classification. By analyzing images of crop leaves these models can learn to distinguish between healthy and diseased crops with remarkable accuracy.

The primary objective of this research work is to get a robust model capable of accurately classifying images of crop leaves into two distinct categories: diseased and healthy. This classification is not only essential for early disease detection but also empowers farmers to make informed decisions regarding disease management strategies, thereby minimizing crop losses and ensuring sustainable agricultural practices.

CNN have revolutionized image analysis tasks by automatically learning features from raw data without the need for manual feature engineering. This work has also conducted a comparative study among some widely used CNN models, viz., VGG-16, VGG-19, AlexNet and GoogleNet. These models were chosen for their proven performance in image classification tasks and their ability to extract intricate features from images at different levels of abstraction.

The dataset utilized in this research work was sourced from Kaggle, a popular platform for machine learning datasets and competitions. The used dataset comprises of a diverse collection of images depicting various crop leaves affected by different diseases across multiple plant species. By leveraging this rich dataset for training and testing the model, researchers were able to ensure robust performance and generalization capabilities across different plant species and disease types.

So the proposed research work showcases the potential of machine learning models, specifically CNNs, in revolutionizing plant disease recognition and management practices. By harnessing the power of advanced technologies like ML and CNNs, researchers and farmers can enhance disease detection accuracy, optimize resource allocation, and ultimately contribute to ensuring global food security and sustainable agricultural productivity.

The next section discusses about different researches done on the relevant fields. The subsequent section deals with the proposed methodology which is followed by the results obtained. A subsection has been dedicated on a comprehensive analysis on the results obtained. The paper concludes with a section dedicated to some proposed future prospects.

2. LITERATURE REVIEW

Different Machine Learning and Deep learning methodologies may offer a promising solution to quickly and accurately diagnose the health of the crops from the images. This approach, while effective, faces challenges and requires further research for optimization and scalability. A significant amount of research has been done to discuss and analyze these issues.

The work depicted by Mohanty et al. [1] had used a public dataset of 54,306 images of diseased and healthy plant leaves collected under controlled conditions and trained a Deep Convolutional Neural Network to identify 14 crop species and 26 diseases. The research also proved that the trained model achieved an accuracy of 99.35% on a held-out test set, demonstrating the feasibility of this approach. The authors also made the dataset and the model publicly available through the project Plant Village 2, which aims to provide a platform for plant disease diagnosis and knowledge sharing. Another research work was done by Hashmat Shadab et al. [2] where a dataset of 2940 images of sugarcane crop leaves with five diseases (or healthy) was used and a VGG-16 model with transfer learning and ensemble techniques was trained. The model achieved an accuracy of 98.7% on the test set and showed better performance than other CNN models, such as AlexNet, VGG-16, and ResNet-50. The authors also tested the model on real-time images captured by a smart phone camera and found that the model was able to diagnose the diseases with high accuracy and speed. Another significant research in this field was by Anwar Abdullah Alatawi et al. [6] where CNN model, specifically VGG16 was used to detect diseases in plants. The model was trained on a dataset from Plant Village, which consisted of 15,915 images of plant leaves, both healthy and diseased. That model demonstrated a high performance, achieving an accuracy of approximately 95.2% and a testing loss of only 0.4418. This indicates that the model was able to correctly classify most of the images in the test set, making it a potentially effective tool for plant disease detection. A review based work was carried out by Majji V Applalanaidu [4] who had provided an organized analysis of various plant disease classification models in well-formed tables. That had included a systematic literature study on the application of the state-of-the-art ML algorithms such as Support Vector Machine (SVM), Neural Network (NN), K-Nearest Neighbor (KNN), Naïve Bayes (NB), and other popular ML algorithms. It had also covered AlexNet, GoogLeNet, VGGNet and other popular DL algorithms for plant disease categorization. The study had also outlined various algorithms' processing methods, including image segmentation and feature extraction and standardized the experimental metrics like dataset size, diseases considered, classifier type, and accuracy percentage. The authors anticipated their work would aid researchers in identifying plant diseases through data-driven methods and had proposed that mobile applications based on machine learning and deep learning will enhance agricultural productivity. A novel approach for plant disease detection based on deep learning was proposed and discussed in [3]. The authors had highlighted the importance of plants in every living organism's life and their contribution to a country's economy. They had also emphasized the need for disease detection in plants for their healthy growth and the negative impact diseases can have on both agricultural crop yield and health. The paper proposed a deep learning-based technique for plant disease detection using the VGG16 architecture. The VGG16 model was used for disease detection in tomato and potato plant species. This multi-class disease detection system had significantly detected diseases and achieved a high accuracy. The paper presents a promising approach to plant disease detection using deep learning, which could potentially contribute to increased agricultural productivity and a healthier natural life cycle. These studies collectively showcase the potential of deep learning methods in revolutionizing crop disease recognition and management practices. By leveraging advanced technologies like deep learning, researchers and farmers can enhance disease detection accuracy, optimize resource allocation, and ultimately contribute to sustainable agricultural practices and improved crop yields.

3. WORKING MODEL

The proposed research work aims to address the critical issue of recognition of diseased or infected crops by leveraging advanced CNN models, specifically VGG-16, VGG-19, AlexNet and GoogLeNet. The implementation process involves a series of steps to effectively train and evaluate these models for accurate classification of crop leaves into healthy and diseased categories.

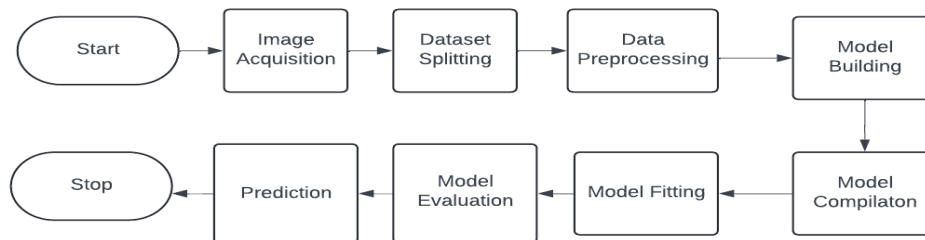


Fig 1. Flow Diagram of Methodology

3.1 Image Acquisition

All the images are acquired by downloading a standard Crop/Plant dataset. The dataset details are given below:
Name: PlantVillage.

The PlantVillage dataset is a rich collection of leaf images from various crops, including apples, potatoes, tomatoes, corn, cherries, and soybeans. Here are the key details:

Source: The dataset is obtained from “Kaggle”, a valuable resource for researchers, and data scientists.

Classes: The dataset comprises 38 classes which we have converted into 2 classes, crop disease or the “healthy” category.

Image Size: Each image is of size 255×255 pixels. And all the images are in RGB format.

3.2 Splitting The Dataset

The entire dataset needs to be split into training and validation sets. This step is crucial in machine learning for effective model development and evaluation. There are several methods to achieve this. Splitting a dataset into training and validation sets is essential for the reasons mentioned next.

- Model Evaluation
- Prevent Overfitting
- Hyperparameter Tuning
- Generalization

3.3 Data Preprocessing

Before feeding the images in the model, essential preprocessing steps are performed.

Here, ‘ImageDataGenerator’ is used from ‘Keras’ deep learning library for these actions, viz., rotation, shearing, rescaling, zooming, shifting the height and width, flipping horizontally, resizing and shuffling that are applied to all the input sample images. After that the pixel values are normalized to a common scale. Normalization enhances model convergence during training. Normalization and resizing functions including shuffle are used for both the training and validation data. For training data specifically, more preprocessing functions are used.

3.4 Model Building

This present research work has utilized four CNN architectures - VGG-16, VGG-19, AlexNet and GoogLeNet which are widely used for their performances in image classification. The models are adapted to meet specific needs, enhancing their capabilities. Developed from scratch, they’re customized to extract task-specific features, ensuring

accurate and efficient image classification. Through mapping input data and correlating processed output with sample output, the models are finely tuned for superior performance.

3.1.1 VGG-16

VGG-16 is a CNN model proposed by Karen Simonyan and Andrew Zisserman from the Visual Geometry Group at Oxford University (11). It gained fame for its impressive performance in the ImageNet Large Scale Visual Recognition Challenge (ILSVRC), where it secured both 1st and 2nd places in the classification and localization tasks, respectively.

3.1.2 VGG-19

VGG-19 was also invented by the same group as VGG-16. It is like the architecture of VGG-16 with three more convolutional layers.

3.3.3 GoogLeNet

GoogLeNet, also known as Inception V1, is a remarkable CNN architecture that made waves in the field of computer vision. GoogLeNet was proposed by researchers at Google, in collaboration with various universities, in 2014.

3.3.4 AlexNet

AlexNet is a pioneering CNN architecture that significantly impacted the field of computer vision. AlexNet was proposed by Alex Krizhevsky, Ilya Sutskever, and Geoffrey Hinton. Compared to previous models like LeNet-5, AlexNet increased the network's depth [15].

3.4 Modifications

Modifications are made to VGG16 and VGG19 models to enhance accuracy and reduce complexity. In VGG16, the last convolution layer block with 3 layers of 512 filters is omitted, and input picture size is set to 48×48 grayscale. Similarly, in VGG19, the last block with 4 layers of 512 filters is removed, with the same input size modifications as VGG16.

3.5 Compiling the Model

Compiling a model configures it for training, specifying optimizer, loss function, and metrics. In the proposed research work, "Adam" optimizer with default learning rate (0.001) is used, alongside options like SGD, Adagrad, Adadelta, RMSprop, Adamax and Nadam. Optimizers can also be used for other purposes. Learning rate, a critical parameter, controls the step size during optimization, determining how quickly a model adapts to error gradient changes. It's essential for fine-tuning model performance.

3.6 Model Fitting

Fitting a model in Keras involves training it on a dataset for a defined number of epochs, using the 'fit' method. This process includes providing training and validation data, specifying batch size and determining the number of epochs. Batch size, a critical hyperparameter, determines the number of samples processed before updating model parameters. Epochs refer to one pass of the dataset through the algorithm, refining the model's ability with each pass. Parameters like `steps_per_epoch`, `validation_steps` and callbacks further optimize training. `Steps_per_epoch` specifies the dataset iterations per epoch, while `validation_steps` determines validation data passes per epoch. Callbacks automate tasks during training, such as Early Stopping to prevent overfitting by halting training when performance plateaus. Model Check point saves the best performing models during training, aiding in model preservation. ReduceLR On Plateau adjusts the learning rate when model improvement stagnates, enhancing learning efficiency. These built-in callbacks in Keras streamline training processes, optimizing model performance and resource utilization.

3.7 Model Evaluation and Prediction

Model evaluation is a crucial step in determining the reliability and accuracy of a production model's performance. It involves analyzing various metrics tailored to the data, algorithm, and use case. For image classification in this work, confusion matrices are created for each model, from which classification metrics are derived. Precision measures true positives among positive class predictions, recall gauges correctly identified positive instances and F1-score balances precision and recall. Additionally, accuracy and loss graphs during training aid in evaluation. Finally, models are deployed for predictions on unseen data, emphasizing their readiness for real world applications. Evaluation and prediction results are detailed in the subsequent section.

4. ANALYSIS

This proposed methodology has been implemented on the Windows 11 platform. The flexibility of Jupyter Notebook has been utilized here as the Integrated Development Environment and the power of Keras, Tensor Flow and other Python packages have been leveraged to train the model.

4.1 Results

To showcase how the accuracy and the loss changes in different epochs for training and validation, accuracy plot and loss plot have been shown. For evaluating the models, confusion matrix has been generated and based on it, different performance metrics like precision, recall, F-1 score, accuracy and error have been calculated.

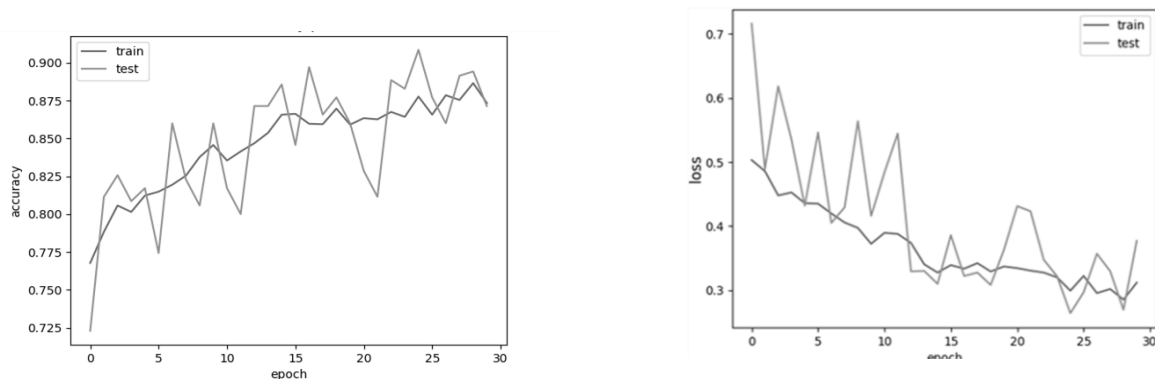


Fig 2. Accuracy Plot & Loss Plot (VGG-16)

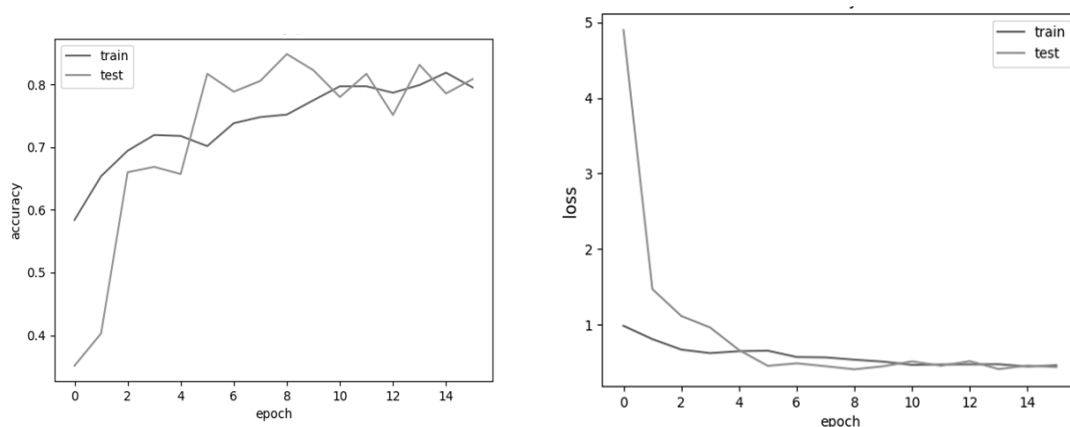
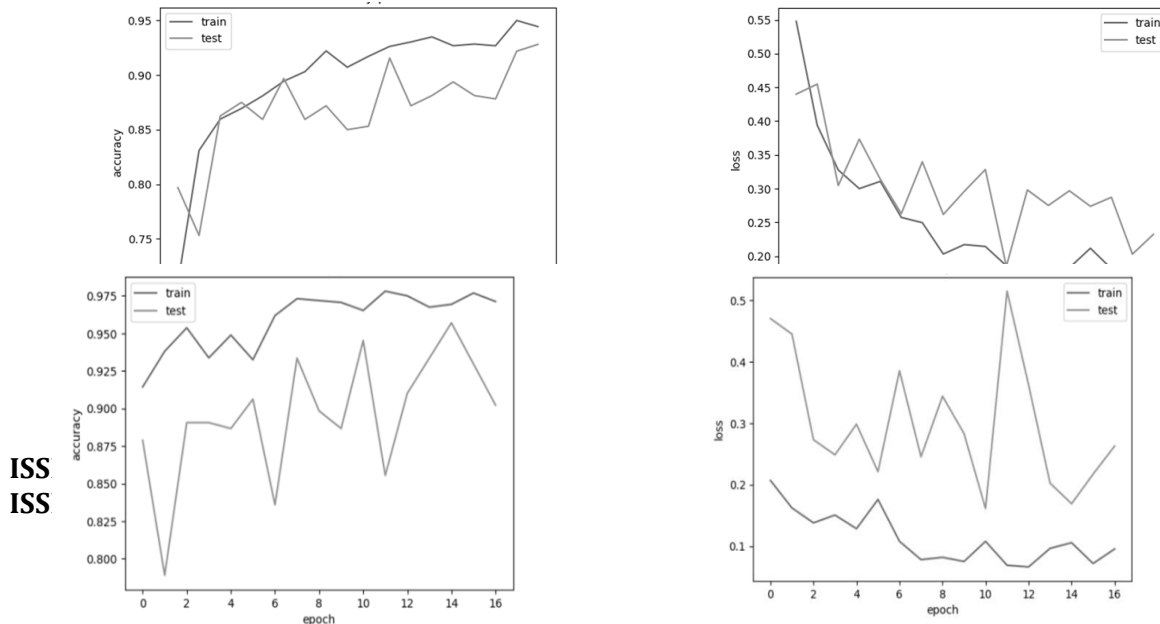


Fig 3. Accuracy Plot & Loss Plot(VGG-19)



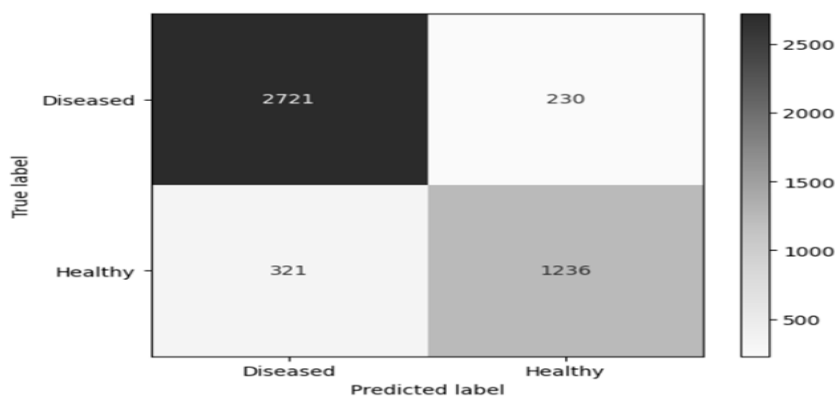


Fig 4. Confusion Matrix for VGG-16

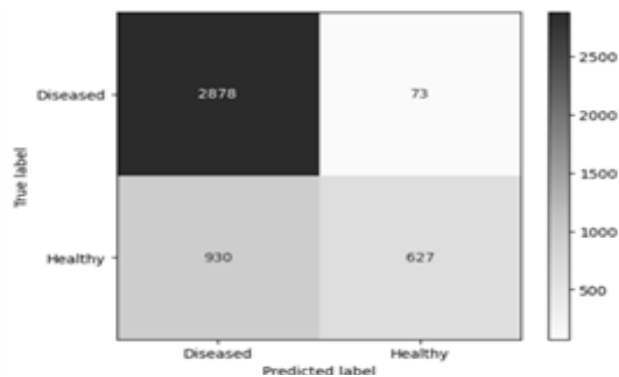
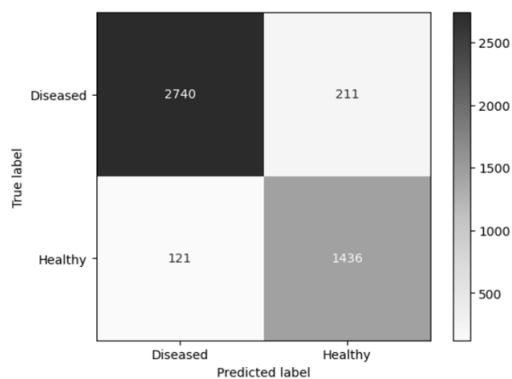
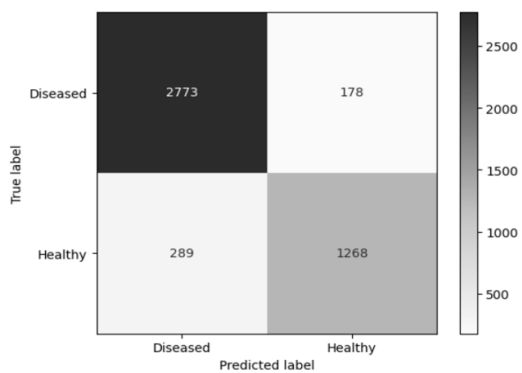


Fig 5. Confusion Matrix for VGG-19



4.2 Analysis

After the results have been obtained based on the different CNN models, they are compared based on some defined parameters as mentioned below:

4.2.1 Accuracy and Loss Comparison

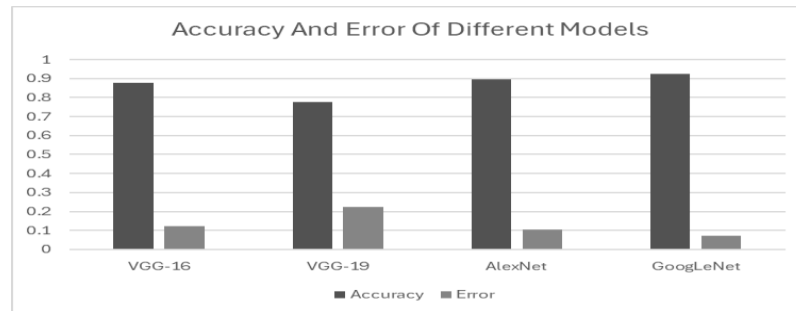


Fig 8. A graphical comparison of Accuracy and Error of different models

Figure 10 depicts the visual representation by providing the precise numerical values for accuracy and error rate for each model. VGG-16, VGG-19, AlexNet and GoogLeNet are clearly outlined with their corresponding accuracy and error metrics. GoogLeNet's dominance is affirmed with an accuracy of 0.926 and an error rate of 0.073, solidifying its position as the most effective model among the ones compared. In conclusion, the comprehensive analysis of the bar graph underscores GoogLeNet's superiority in accurately classifying normal and diseased conditions, making it the optimal choice for this specific machine-learning task.

4.2.2 Precision, Recall, F1-Score Comparison

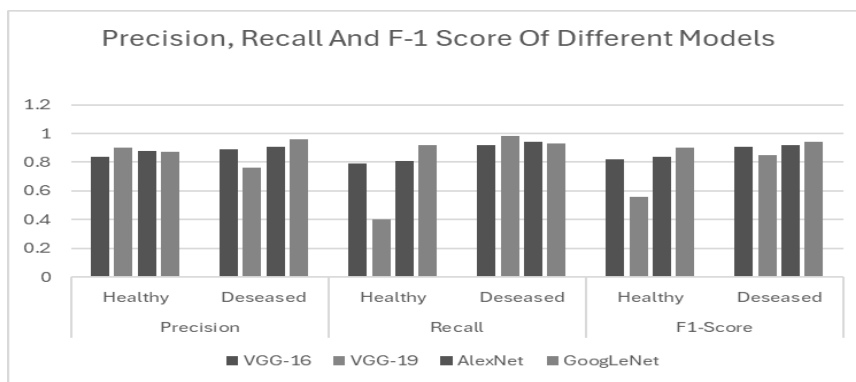


Fig 9. Comparison graphs of Precision, Recall, F1-Score for different models

For the four models under analysis, evaluation of different metrics like precision, recall and F1-score was done for both healthy and diseased conditions. While precision measures the accuracy of positive predictions, recall measures the completeness of positive predictions. The F1 score is particularly useful in cases where there is a trade-off between precision and recall.

VGG-16 demonstrates high precisions for both the healthy (0.84) and the diseased (0.89) conditions. Its recall is also commendable for the healthy (0.79) and diseased (0.92) conditions. However, its F1-score for the Healthy condition is relatively low (0.82) compared to the diseased condition (0.91).

VGG-19 exhibits a higher precision for both the healthy (0.90) and the diseased (0.76) ones. Its recall value for the healthy condition is lower (0.40) than what has been obtained through VGG-16 but the same is higher for the diseased condition (0.98). However, there is a heavy decrease of F1-score in the healthy condition (0.56) compared to the diseased condition (0.85).

AlexNet shows a higher precision for the diseased condition (0.91) but lower for the healthy condition (0.88). Its recall values for both the said conditions are comparable to VGG-16 and VGG-19 with a slight decrease in the healthy condition (0.94) and an increase in the diseased condition (0.94). The F1-scores for both the conditions are almost like VGG-16 and VGG-19 with a slight decrease in the healthy condition (0.84) and the diseased condition (0.92).

Finally, GoogLeNet outperforms the other models with a higher precision for both the healthy (0.87) and diseased (0.96) conditions. Its recall is also impressive for both the conditions with a slight decrease in the healthy condition (0.92) and a significant increase in the diseased condition (0.93). The F1-scores for both the conditions are the highest among all the models under consideration with a slight decrease in the healthy condition (0.90) and a significant increase in the diseased condition (0.94).

After rigorous experimentation and evaluation, it has been found that GoogLeNet has exhibited a superior overall performance, effectively balancing precision and recall, making it the most suitable model for classifying normal and diseased conditions. This finding highlights the importance of selecting an appropriate CNN architecture based on the specific requirements of the task at hand.

5. CONCLUSION

The proposed research work has utilized different CNN models to classify healthy and diseased leaves from a dataset. The most significant part of this research work has been the comparative study conducted among VGG-16, VGG-19, AlexNet and GoogLeNet on leaf images of various crops. This study has yielded quite a few significant findings. Among the models evaluated, GoogLeNet has been emerged as the standout performer, showcasing exceptional precision and recall values for both the normal and diseased conditions. Its ability to strike a balance between these key metrics positions it as the most suitable model for accurately classifying the health status of crops based on leaf images.

Delving deeper into the analysis of loss and accuracy trends, VGG-19 stands out for its stability and consistency, exhibiting smoother curves compared to VGG-16. AlexNet mirrors VGG-19's behavior but with slightly more pronounced fluctuations, suggesting potential benefits from fine-tuning hyperparameters. On the other hand, GoogleNet's performance appears to be intricately linked to training dynamics, indicating a need for meticulous adjustments to its architecture for optimal results.

The outcomes of the research underscore the importance of not only selecting the right model but also fine-tuning parameters to enhance generalization and overall performance. These insights can be leveraged to advance the development of more precise and efficient models for crop disease detection, thereby contributing to the enhancement of agricultural practices and bolstering food security measures.

In conclusion, the findings endorse GoogLeNet as the preferred model for distinguishing between healthy and diseased crop conditions, owing to its remarkable precision-recall balance. Future endeavors can focus on refining the model's architecture and training strategies to further elevate its efficacy and resilience in real-world applications within the agricultural sector. This research work serves as a stepping stone towards harnessing advanced technology for the benefit of crop health monitoring and agricultural sustainability.

REFERENCES

1. Sharada P. Mohanty, David P. Hughes, and Marcel Salathé. "Using Deep Learning for Image-Based Plant Disease Detection", *Front. Plant Sci.*, 22 September 2016, Sec. Technical Advances in Plant Science. Volume 7, Article 1419, doi 10.3389/fpls.2016.01419.
2. Malik Hashmat Shadab¹, Mahavir Dwivedi², SN Omkar, Tahir Javed, et al. "Disease Recognition in Sugarcane Crop Using Deep Learning". Published: 2019/09/23, doi: 10.13140/RG.2.2.21849.47209.
3. Alok Kumar, Ankit Kumar. "Plant Disease Detection using VGG16". *International Journal of Creative Research Thoughts (IJCRT)*. Volume 11, Issue 1 January 2023.
4. M. V. Applalanaidu and G. Kumaravelan, "A Review of Machine Learning Approaches in Plant Leaf Disease Detection and Classification," 2021 Third International Conference on Intelligent Communication Technologies and Virtual Mobile Networks (ICICV), Tirunelveli, India, 2021, pp. 716-724, doi: 10.1109/ICICV50876.2021.9388488.
5. Gnanavel Sakkarvarthi¹, Godfrey Winstersathianesan¹, Vetri Selvan Murugan, Avulapalli Jayaram Reddy, Prabhu Jayagopal³ and Mahmoud Elsisy. "Detection and Classification of Tomato Crop Disease Using Convolutional Neural Network". 2022, 11, 3618. <https://doi.org/10.3390/electronics11213618>.
6. Anwar Abdullah Alatawi, Shahd Maadi Alomani, Najd Ibrahim Alhawi, Muhammad Ayaz. "Plant Disease Detection using AI-based VGG-16 Model". (IJACSA) *International Journal of Advanced Computer Science and Applications*, Vol. 13, No. 4, 2022.
7. G. Mahesh Reddy, P. HemaVenkata Ramana, Ponnuru Anusha, Baula Kalyan Chakravarthy, Aravinda Kasukurthi, VaddempudiSujatha Lakshmi. "A Survey on Sugarcane Leaf Disease Identification Using Deep Learning Technique(CNN)". *International Journal on Recent and Innovation Trends in Computing and Communication*, 16 April 2023, Volume: 11 Issue: 5 Doi:<https://doi.org/10.17762/ijritcc.v11i5.6611>.
8. Karen Simonyan & Andrew Zisserman. "Very Deep Convolutional Networks For Large Scale Image Recognition", Published as a conference paper at ICLR 2015, doi 10.48550/arXiv.1409.1556.
9. VGG16 - Convolutional Network for Classification and Detection (neurohive.io), <https://neurohive.io/en/popular-networks/vgg16/>, last accessed: 23/11/2023.
10. Crop Disease Detection Using Machine Learning and Computer Vision – Kdnuggets, <https://www.kdnuggets.com/2020/06/crop-disease-detection-computer-vision.html>, last accessed: 23/11/2023.
11. Understanding VGG16: Concepts, Architecture, and Performance (datagen. tech), <https://datagen.tech/guides/computer-vision/vgg16/>, last accessed: 23/11/2023.
12. Plant Disease Detection using VGG16, Kaggle, <https://www.kaggle.com/code/amitkrjha/plant-disease-detection-using-vgg16>, last accessed: 23/11/2023.



13. Introduction to Convolutional Neural Network (CNN) using TensorFlow by Govinda Dumane Towards Data Science, last accessed on 15/03/2024.
 14. VGG16 - Convolutional Network for Classification and Detection (neurohive.io), last accessed: 15/03/2024.
 15. Alexnet Architecture | Introduction to Architecture of Alexnet (analyticsvidhya.com), last accessed: 15/03/2024.
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STOCK MARKET PRICE PREDICTION USING POLYNOMIAL REGRESSION

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ABSTRACT

The price trend of financial market is perplexing and is affected by different factors. The investigation of the Stock market draws attention from financial specialists and analysts. Therefore, finding the price trend and factors influencing the stock market is important. In this paper, we have applied forward feature selection algorithm on technical indicators to find the most significant feature affecting the change in stock price and further using a polynomial regression model to predict stock price movement.

KEYWORDS. *Technical Indicator; Forward Feature Selection; Polynomial Regression*

1. INTRODUCTION

The unpredictability of the stock market affects many people and industries. Prediction for the stock market is a sought-after domain for many financial consultants and individuals. It can also act as an early warning for market distress. Various stock prediction models exist using macroeconomic factors [1]. In this paper, we suggest the use of market indicators that is technical indicators, and the classical polynomial regression model determine prices and its trend using other machine learning algorithms. The computed data of the Technical Indicators serve as a historical data set for the regression. An empirical study of the above method has been done on the NIFTY 50 stock which is successful in generating a high accuracy score. The stock market generates a huge amount of data. A stock market is primarily governed by various factors like current news, buyer-seller equilibrium, political events, economic indicators, the performance of a company et cetera. People have also used theoretical foundation in mathematics and statistics to analyze price trends of stocks using modern computation power. The advanced development in the field of machine learning and artificial intelligence has drawn attention to find its use in the field of finance. Researchers have used Support Vector Machines, Artificial Neural Network, Deep Learning models to predict stock prices in the past [2][3]. Machine learning is a learning algorithm that can recognize patterns easily and predict future price trends. We have used a machine learning technique using a regression model to determine the relationship between a dependent variable and one or more independent variables. Here, the independent variables are the value of the different technical indicators computed and the dependent variable that we would like to predict is the price.

2. TECHNICAL INDICATORS

Technical analysis and fundamental analysis are the major schools of thought when it comes to approaching markets. Technical analysis is a study of stock price pattern movement in the past, while fundamental analysis looks at the company's financial condition. Technical indicators are a proper noun in finance [4]. It is mathematical calculations based on the historical price, current price and the volume activity. Technical analysts use this information to evaluate historical performance and to predict future prices. The technical indicators can be further classified into the following: We have computed a few of the indicators from all the various types which are likely to give us a higher variance in the computed dataset [5].

The NIFTY50 is a stock index of 50 Indian companies, ranging from different industries. The degree of change in the index is calculated through a weighted average of changes in the stock prices of the constituent companies. NIFTY50's historical values had been fetched from yahoo finance India (Date- 1/1/2016 to 18/4/2019). It includes Open, High, Low, Close, Volume, Adj Close column-wise. Values returned from various technical indicators were added column-wise. On computing the values of the different technical indicators, we generate a lot of rows with null values which was dropped from the data set. Technical Indicators suffer from the problem of multicollinearity as the data set has different technical indicators of the same type [6].

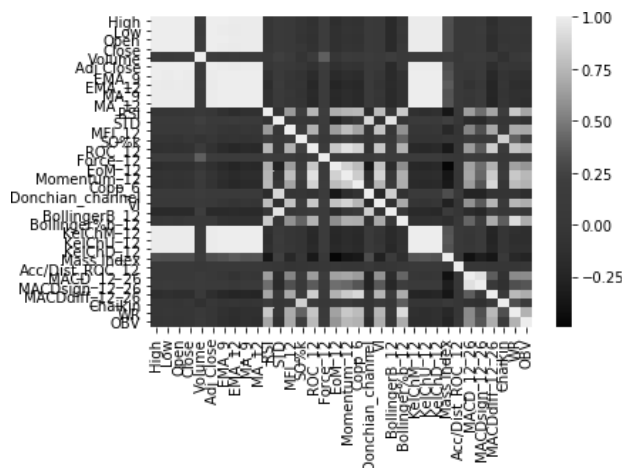


Fig 1. Correlation among features.

DIFFERENT TYPES OF TECHNICAL INDICATORS

Trend	Average directional index (A.D.X.), Commodity channel index (CCI), Detrended price oscillator (DPO), Know sure thing oscillator (KST), Ichimoku Kinko [−] Hyo [−] , Moving average convergence/divergence (MACD), Mass index, Moving average (MA), Parabolic SAR (SAR), Smart money index (SMI), Trend line, Trix, Vortex indicator (VI).
Momentum	Money flow index (MFI), Relative strength index (RSI), Stochastic oscillator, True strength index (TSI), Ultimate Oscillator, Williams %R (%R).
Volume	Accumulation/distribution line, Ease of movement (EMV), Force index (FI), Negative volume index (NVI), On-balance volume (OBV), Put/call ratio (PCR), Volume-price trend (VPT).
Volatility	Average true range (ATR), Bollinger Bands (BB), Donchian channel, Keltner channel, CBOE Market Volatility Index (VIX), Standard deviation (σ).

Each feature had been normalized using the formula: $x[i] - \min(x)/(\max(x) - \min(x))$. Since Regression performs better with feature scaling as each variable gets equal weight-age to work on with [7].

FORWARD FEATURE SELECTION

Feature selection model is needed because the processing of high dimensional data can be very challenging and such an

algorithm removes redundant features [8]. Regression can easily overfit to such high dimensional data [9]. Having fewer dimensions also adds to the less computational time, lesser variance and more interpretable model. The algorithm uses the Cross-validation model while training the model [10]. The features which occur in 3 or more time in the 5 cross-validation system are chosen in the final training dataset. Since we have a dynamic data set that is values being generated on a daily basis, we may need to run the forward feature selection algorithm a several times in order to discard a few fluctuations in the selection of features in the final training data set.

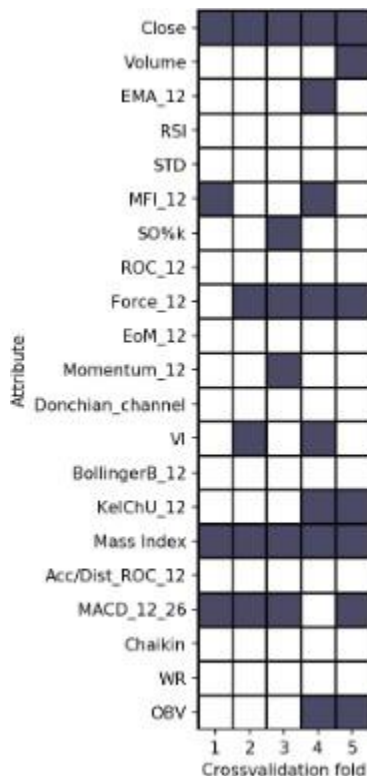


Fig 2. Output of forward feature selection using five cross- validation fold

POLYNOMIAL REGRESSION

The polynomial models can be used in those situations where the relationship between study and explanatory variables is curvilinear. Sometimes a nonlinear relationship in a small range of explanatory variable can also be modeled by polynomials. The k th order polynomial model in one variable is given by $y = \beta_0 + \beta_1x + \beta_2x^2 + \dots + \beta_kx^k + \varepsilon$.

If $x_j = x_j$, $j=1,2, \dots, k$, then the model is multiple linear regressions model in k explanatory variables that is $x_1, x_2, \dots, x_k$. So the linear regression model $y = X\beta + \varepsilon$, ε includes the polynomial regression model. Thus, the techniques for fitting linear regression model can be used for fitting the polynomial regression model [11]. In Polynomial regression we increase the complexity of the model. It is used to overcome under fitting, which was a drawback of linear regression model. We have converted the original features into their higher order terms using Polynomial Feature class in scikit-learn. If we increase the complexity that is degree of the model, then it is capturing the noise in the data which leads to overfitting.

RESULTS

The results below are obtained after feature scaling and selection:

The result generated for 21 days using all the possible features and no normalization for we get a score of 0.85 and mean squared error of 69309.785.

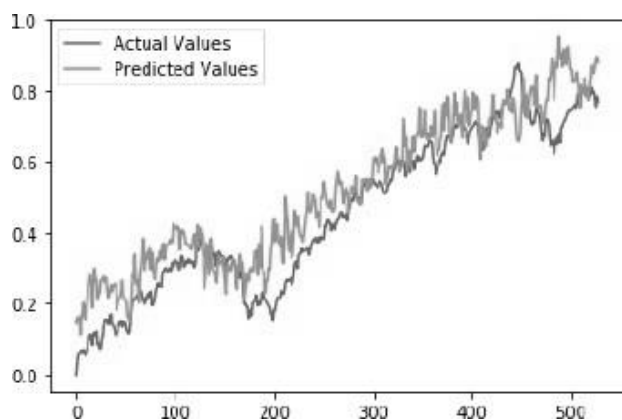


Fig 3(a): Actual price and predicted price graph for a period of 136 days

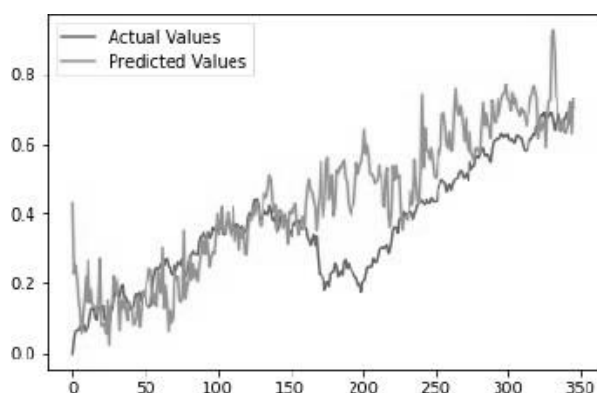


Fig 3(b): Actual price and predicted price graph for a period of 96 days

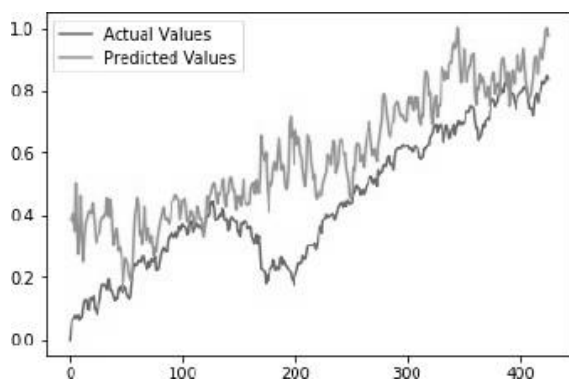


Fig 3(c): Actual price and predicted price graph for a period of 21 days

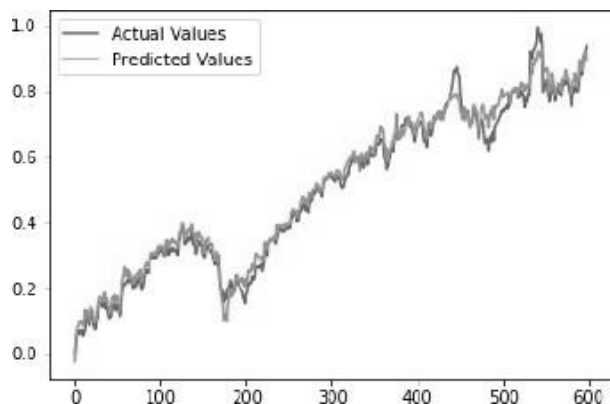


Fig 3(d): Actual price and predicted price graph for a period of 10 days

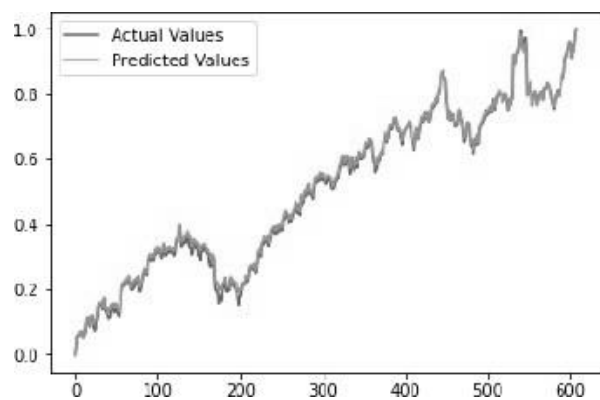


Fig 3(e): Actual price and predicted price graph for a period of 5 days

THE RESULTS OBTAINED AFTER FEATURE SCALING AND SELECTION :

days	features chosen	accuracy	mean squared error
5	Close, Bollinger Band	0.98	0.00142
10	Close, Force, Mass Index, MACD	0.96	0.00238
21	Close, Force, Mass Index, MACD, OBV	0.95	0.00291
96	Standard deviation, MFI, Channel, OBV, MACD, Keltner	0.83	0.00871
136	Bollinger Band, Mass Index	0.84	0.00691

	Volume, Ease of Momentum, RSI		
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CONCLUSIONS

Polynomial Regression, as we find out from that model works best when the dataset is normalized, and fewer features are used. The dataset is normalized based on a standard formula so that all the columns have a domain of 0 to 1. Data normalization in regression ensures that a robust weighted relationship is formed among the features. Further, in order to avoid overfitting, we used a polynomial of degree 2. When the model was tried with other higher degrees the training dataset was over fitted and generated noise as a result was giving a low score on the test dataset. Similarly, a low score was obtained when all the features were used in the regression model since the dimensionality of the data was high. Few dominant features were chosen based on the forward feature selection algorithm. The data set is a dynamic time series data, as a result of which when the machine learning model of feature selection is run several times, there is sometimes a fluctuation in the result. The predicted value for a short time window frame is successfully able to give accurate results. As the time frame increases the model is successful in giving the trend of the stock rather than pinpointing the stock price. The result of such behavior is primarily because of the exclusion of other factors in the model. With a better stock price prediction algorithm, we can help investors by serving as a reference for a better trading strategy.

REFERENCES

1. V. Kapoor, N. Khedkar, J. O. Qiao, S. Venkatesan, and S. Laghate, "Predicting Volatility in the S&P 500 through Regression of Economic Indicators."
2. S. P. Das and S. Padhy, "Support Vector Machines for Prediction of Futures Prices in Indian Stock Market," march 2012.
3. G. E. Hiransha M, V. K. Menon, and S. K.P, "NSE Stock Market Prediction Using Deep-Learning Models (June 2018)." NSE Stock Market Prediction.
4. L. Blume, D. Easley, and M. O'Hara, "Market Statistics and Technical Analysis: The Role of Volume. The Journal of Finance (1994)." The, 1994.
5. Justin and Kuepper, "Technical Analysis: Indicators And Oscillators," 2019. [Online]. Available: <https://www.investopedia.com/university/technical/technicalanalysis10.asp>
6. C. Mela and K. KOPALLE, "The impact of collinearity of regression analysis: the asymmetric."
7. J. Han and M. Kamber, *Data Mining: Concepts and Techniques*. Second edition, 2006.
8. B. D. W. H, "A Formalism for Relevance and its Application in Feature Subset Selection."
9. I. M. Johnstone and D. M. Titterton, "Statistical challenges of high- dimensional data (November 2009)." Iain M. Johnstone1 and D. Michael Titterton, *Statistical*.
10. S. Arlot and A. Celisse, "A survey of cross-validation procedures for model selection," 2009.
11. E. Ostertagová, "MODELLING using polynomial regression," 2012.



**BHAKTISIDDHANTA SARASVATI THAKUR AND ‘SARASWAT
CHATUSPATHI’ IN THE FIELD OF VEDIC ASTRONOMY IN COLONIAL
BENGAL – A CASE STUDY BASED ON THE PERIODICALS, *JYOTIRBID*
AND *BRIHASPATI* AND THE ALMANAC *BHAKTIBHAVAN* OR
*NABADWIP PANJIKA***

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ABSTRACT

During the colonial period, the English-educated Bengali middle-class intelligentsia recognized the need to reform the Gaudiya Vaishnava community from the moral degradation and corruption that had become prominent after the Caitanya age. To achieve this, the Vaishnava periodicals played a significant role in creating awareness among the devotees and initiating a print culture of ‘Piety’ (Dey, 2020). These publications not only helped their readers develop an understanding of the true essence of the religion, but also convinced them that it was the greatest and most righteous option for people. Gaudiya Vaisnavism’s universal acceptance was not solely based on its scriptural finesse, but was also a product of its rational nature, where scientific observations were used to justify the religiosity of the community. Two periodicals on Hindu Astronomy (Jyotirbid and Brihaspati) by Bhaktisiddhanta Sarasvati Thakur played a significant role in making Gaudiya Vaishnavism more popular amongst the educated Bengali middle-class devotees due to its realism. Even the celebration of Vaishnava festivals was decided on the basis of astronomical calculations mentioned in these journals, along with the birth and death anniversaries of famous Vaishnava gurus (Dey, 2020). This paper aims to revisit the history of Vedic or Hindu astronomy through the lenses of Gaudiya Vaishnavism in colonial Bengal. Here we need to highlight the life and works of Bhaktisiddhanta Sarasvati Thakur, the founder of the Gaudiya Math and Mission, who established the ‘Saraswat Chatuspathi’ in colonial Calcutta in 1897 to promote Hindu astronomy. Perhaps no other religion in the colonial period had taken such a stance to prove its worth not only in the light of spiritual doctrines but also from the perspectives of scientific humanism. His expertise in science played an important role in mobilizing Gaudiya Vaishnavism amongst the Bhadrakal community of modern Bengal, thus creating a niche for scientific nationalism and religious revival.

KEYWORDS. *Gaudiya Vaishnavism, Astronomy, Colonial Bengal, Journals, Almanac*

1. INTRODUCTION

Finding space for Bengali *Masik Patrika* /periodicals /journals with a religious background that supported national science in colonial Bengal perhaps is a challenge. Scholars such as Sarvani Gooptu (2022)¹ and Samarpita Mitra (2020)² have discussed in their publications how Bengali periodicals attempted to raise awareness about politics, economy, gender, and society. Indrani Das Gupta’s recent publication (2023)³ talks about science in vernacular based on the science fiction of Sukumar Ray. Julian Strube, in his article, “(Anti-)Colonialism, Religion, and Science in Bengal from the Perspective of Global Religious History,” (2022)⁴ shows how a tantric scholar, Shivachandra Bhattacharya Vidyarnava, and his followers attempted

to elevate Tantra Dharma in the light of the main texts translated into English. Santanu Dey (2020) mentions how the Bengali *Bhadralok* society spread the ideology of mercy or piety of Gaudiya Vaishnavism in colonial Bengal through the periodicals.⁵ My contribution is highlighting how a Vaishnava reformer tried to spread national science in the vernacular, emphasizing secularism and inclusiveness.

My proposed paper aims to revisit the history of Hindu Astronomy and Astrology through the lenses of Gaudiya Vaishnavism in colonial Bengal. Here we need to highlight the life and works of Bhaktisiddhanta Sarasvati Thakur (1874-1937), the founder of the Gaudiya Math and Mission (1920). who established 'Calcutta Saraswat Chatuspathi' in 1897 to facilitate the learning of Hindu Astronomy and Astrology. He published *Jyotirbid*, *Brihaspati* and *Bhaktibhavan* or *Nabadwip Panjika* with an aim to promote Astronomy and Astrology in vernacular as the forms of Indian or national science where Astronomical data validated the chronology and periodization of the tradition of Gaudiya Vaishnavism. At the request of Vice-chancellor Asutosh Mukherjee, he was appointed as the Chair of Astronomy at Calcutta University due to his reputation as an Astronomer.⁶ Perhaps these above-mentioned initiatives helped the Gaudiya Vaishnava Community to prove its worth not only in the light of spiritual doctrines but also from the perspectives of scientific humanism.

2. HISTORICIZING *JYOTISHA* OR ASTRAL SCIENCE: GLIMPSES FROM THE PREVIOUS RESEARCH

There are several researches on Astral Science in colonial India. But there is perhaps very little research on print culture in Astronomy or astronomical journals. Caterina Guenzi (2021),⁷ in her book, talked about the colonial response towards Indian Astronomy and Astrology, where the Indians also joined hands with the British to prove the worth of Hindu Astral Science. Nupurnima Yadav (2022)⁸ defined the meaning and scope of *Jyotisha* and its inadvertent projection through Astrology. Ankur Kakkar (2022),⁹ in his article, highlighted how the Europeans looked at Indian astronomy, whereas, S. Prashant Kumar (2022)¹⁰ wrote about the south Indian experience of Astronomy in colonial Madras based on caste politics. R.C. Kapoor (2023),¹¹ in his recent article, has shown how the colonizers established observatories and pursued research on astral science which also became 'an element of empire in British India'.¹² S.N. Sen and K.S. Shukla (1985)¹³ highlighted the history of Astronomy in India in their book, *History of Astronomy in India*. Rana P.B. Singh (2023)¹⁴ and Pavaneshwar Das (2022)¹⁵ highlighted the discourses on cultural or Vedic Astronomy through their research. I have emphasized the recent studies to understand how my observations can create new dimensions in the history of astral science in India from the perspectives of a specific religious community.

3. PROPAGATING ASTRAL SCIENCE IN VERNACULAR: IN THE WORDS OF BHAKTI SIDDHANTA SARASVATI, EXCERPT FROM HIS WRITINGS

I would like to quote Bhakti Siddhanta Sarasvati to understand how he tried to promote traditional astral science and what was the need for propagating the same in vernacular. His expertise on the subject also reflected his awareness on the development of astronomy through print culture in the other parts of colonial India.

"In Bengal, there are few readers or '*pathoks*'. Many people are interested in reading books, but they often face difficulties in accessing them. It is especially difficult to find readers interested in scientific topics. Publishers are reluctant in publishing scientific books due to the lack of readers. In the Western society, there are plenty of periodicals on science and arts. However, in our country, there are only two-three periodicals on medical science, two

periodicals on agriculture and industry, and no periodicals on *Jyotisha Sastra*. We have felt the absence of a periodical on *Jyotisha* for a long time. Recently, one periodical on marine science has been published in Calcutta, and there is one periodical on *Jyotisha* in English we have found in Madras. However, there is no *Patrika* on *Jyotisha* that talks about planetary positions determined by Mathematical calculations and projects the *Mimansha* or the annotations by the ancient sages...

Western astronomy is advancing rapidly. It is discovering new planets, taking pictures of the universe with the help of *Alokbigyan* or optics, measuring the speed/space velocity of the stars with *Varnabicchayed Jantra* or sextant, and developing further. We believe that our educated society should discuss *Jyotisha Sastra*, which is one of the most important components of the *Vedas*... Through this *Patrika*, we aim to publish translations and illustrations of all *Prachin Arya Sastra* or Aryan knowledge systems. We will publish articles on understanding planetary positions through Western Mathematical calculations. Many people often show disinterest in *Jyotisha*, which they believe is a form of cheating people. However, those who have this belief should read the ancient texts to get rid of their mental blockages...

Presently, people are interested in revealing the mysteries of Applied or *Falita Jyotisha* and learning about its objectives and usefulness. Those who believe that *Bharatiya Prachin Sastra* is irrational and does not talk about *Satya Vigyan* or natural science, and that our forefathers merely copied Western Science and incorporated it into ancient texts should explore the ancient scriptures themselves to overcome their misconceptions...¹⁶

4. UNDERSTANDING *JYOTISHA* THROUGH THE LENSES OF SIDDHANTA SARASVATI'S RESEARCH: DECODING THE SCOPE OF ASTRAL SCIENCE IN HIS WORKS: CERTAIN GLIMPSES

Siddhanta Saraswati mentioned both Astronomy and Astrology as the *Jyotisha Sastra*. However, his emphasis was more on Astronomy, he also taught Astrology in Saraswat Chautuspathi to train professional Astrologers. In the first volume of *Jyotirvid* (1901), he cited the views of famous astronomer Norman Lockyer (1836-1920), who mentioned how Sunspots can affect Earth's climate. Siddhanta Saraswati mentioned national progress depends on the preservation of the discourses on *Jyotirvidya* or Astronomy and the educated people should dedicate themselves in this regard. He used the word *Charankya* for Logarithm and quoted Pierre –Simon Laplace (1749-1827), the French Mathematician.¹⁷ Siddhanta Saraswati wrote, *Jyotirvid* would help the readers to access the rare books on *Jyotirvigyan* or Astronomy.¹⁸ In the journal *Brihaspati*, he outlined how to use Western Mathematics to calculate planetary orbits or *Grahananita*.¹⁹

Siddhanta Saraswati wanted to honor the ancient Indian mathematician Bhaskaracarya and claimed that in *Bhuvankosh*, Bhaskaracarya wrote about gravity long before Newton did. Even in *Siddhantasiromani*, he discussed the same theories that were echoed five hundred years later in the writings of Leonhard Euler, a Swiss Mathematician.²⁰ Bhaktisiddhanta Saraswati Thakur translated *Siddhantashiromani* into Bangla and wanted to promote *Siddhanta Jyotisha Sastra* in Bengal.²¹ He translated and annotated the Sanskrit text, *Sri Surya Siddhanta* for which he received the title, Siddhanta Saraswati or the Epitome of Wisdom by his teachers, Pandit Mahesh Chandra Churamani and Pandit Sundar Lal.²²

He explained Western Astronomical concepts like Parallax and Obliquity of the Ecliptic in the journal *Brihaspati*. He proved them using Western Mathematics, all written in Bangla language. Siddhanta Saraswati mentioned Greenwich time in London with calculations. Siddhanta Saraswati believed that scientific knowledge was a source of power or *बल* that could help people grow. For him, educating Bengalis about *Jyotirbiggyan* or Astronomy could help them prosper as a nation. He mentioned that amongst the ancient Indian Sciences, *Kal Sastra* holds a higher position.²³ According to him, *Kalvidya* is known as *Jyotirvidya*, and his journals discussed *Kal* in various forms. Siddhanta Saraswati condemned

the periodicals of his times for being less critical and more commercial. He emphasized how his readers could understand the essence of *Jyotirvishaya* or everything about *Jyotisha* through his publications. He wanted to endorse *Hindu Jyotisha* with English Astrology and Western Mathematics.²⁴

5. Introducing জ্যোতির্বিদ (JYOTIRBID) AND বৃহস্পতি (BRIHASPATI) : CERTAIN KEY ASPECTS

Both these journals helped us to understand the confluence of the Indian and the Western forms of Astronomy and Astrology. They pioneered national science in the vernacular by translating *Prachin Arya Sastra* or the traditional Sanskrit texts of Hindu Astral Science. *Brihaspati* was also known as 'The Scientific Indian'. The aforementioned journals also aimed to promote astrology as a legitimate science rather than a method of deceiving people. They acknowledged the importance of Astronomy as the traditional branch of knowledge, similar to Indian philosophy and Ayurveda. These journals of Siddhanta Sarasvati encouraged 'print culture' in astral science like the western countries. They taught western Mathematics for learning Hindu Astronomy. These journals took initiatives to inform readers about the origin and development of scientific knowledge worldwide. *Brihaspati* mentioned the establishment of The Royal Geographical Society and Royal Horticultural Society in London during the 1880s.²⁵

These journals promoted Astronomy and Astrology as the integral parts of the Hindu culture, depicting every moment of life starting from birth to death. *Jyotirvid* and *Brihaspati* also translated works on English astronomy for the convenience of the readers. They tried made the subscribers aware about the practical applications of Astronomy, such as predicting solar and lunar eclipses, weather patterns, time differences, providing directions, its crucial role in marine science etc.²⁶ These journals promoted books on Astronomy. As for example, *Jyotirvid* encouraged its readers to purchase books like "Book of Fate" or "Principles of Hindu Astrology" authored by Mr. K. Dutt, who was also the co-editor of the same journal.²⁷

6. কলিকাতা সারস্বত চতুষ্পাঠী (CALCUTTA SARASWAT CHATUSPATHI) : THE CENTRE FOR LEARNING ASTROLOGY

Bhaktisiddhanta Sarasvati Thakur founded the Calcutta Saraswat Chatuspathi at 181 Maniktola Street, Rambagan, Calcutta. The purpose of this institute was to teach Astrology to aspiring astrologers who wanted to make it their profession after passing the government and other degree examinations. The students who graduated from this institute excelled in their profession and were even awarded scholarships by the government. One such example is Srijukta Hara Gaurishankar Jyotirvinod, whose reference we find in the *Jyotirbid* journal.²⁸

This institute was not residential and it had a great collection of books on Astronomy and Astrology. The students could use the library facilities, but they needed to take permission from the Principal and Librarian. The school aimed to train professional Astrologers as well as those who had an interest in the subject. The students were also taught English Astronomy, Astrology and Western Mathematics. Bhaktisiddhanta Sarasvati wanted to educate Indian Astrologers like the Astrologers of other countries. The Saraswat Chatuspathi followed the tradition of the ancient Gurukul system, and the Professors used to give honorary titles to the meritorious students. Patrons would often donate to this school of Astrological excellence.²⁹

The education at Saraswat Chatuspathi was free of cost, and its sole purpose was to spread the knowledge of Astronomy and Astrology. As it was mentioned, '*Jyotish Shastra prochar korai Chahtuspathir ekmatro uddeshyo*'.³⁰ The Chatuspathi had facilities for membership and donation. Patrons and members had the privilege to use the library or could send someone to take notes on their behalf. The institute also had publication facilities, where interested authors were invited to publish books, essays, and journals.³¹



The Chatuspathi published বঙ্গ পঞ্জিকা সংস্কার (*Bange Panjika Samskar*) compiled by Pandit Satkari Chattopadhyay Siddhantabhusan with an English introduction of twelve pages to guide the writers of almanacs on how they can calculate like *Bishuddha Siddhanta Panjika* with the help of Western Mathematics along with other instructions.³² Bhaktisiddhanta Sarasvati Thakur published *Almanac for the year 1917* from this Chatuspathi (Sardella, 2012).³³

7. THE ALMANACS- *BHAKTIBHAVAN* OR *NABADWIP PANJIKA* AND *SRI CAITANYA PANJIKA*

Bhaktibhavan Panjika published by Bhakti Siddhanta Sarasvati Thakur was designed for the devotees and written in simple Bangla language. Still this almanac gets published from Sri Caitanya Math, Mayapur, West Bengal. Here we get references of three types of calendars based on AD or খ্রিস্টাব্দ, Bangla solar calendar or বঙ্গাব্দ and শ্রীগৌরব্দ (Sri Gaurabda), the lunar calendar which has counted from Sri Chaitanya's appearance day. It talks for twelve months which have the various names of Krishna. These are such as বিষ্ণু (Vishnu), মধুসূদন (Madhusudan), ত্রিবিক্রম (Trivikram), বামন (Baman), শ্রীধর (Sreedhar), হৃষিকেশ (Rishikesh), পদ্মনাভ (Padmanava), দামোদর (Damodar), কেশব (Keshab), নারায়ণ (Narayana), মাধব (Madhab) and গোবিন্দ (Govinda). The days to perform rituals or ব্রত and to keep fast or উপবাস are used to be mentioned in the almanac according to the decisions taken by the eminent Vaisnava Gurus or শুদ্ধবৈষ্ণব সিদ্ধান্তানুসারে. The almanac also contains the dates for তিথিপূজা or religious celebrations, including the appearance and disappearance days of famous Vaisnava Gurus. The almanac provides information about the history of Gaudiya Vaishnavism and highlights important pilgrimages associated with it.³⁴ Siddhanta Sarasvati also published *Sri Caitanya - Panjika* or *Sri Mayapur-Panjika* to promote print culture for almanacs.³⁵

8. SITUATING BHAKTI SIDDHANTA'S EXPERTISE IN ASTRAL SCIENCE AND THE SPREAD OF GAUDIYA VAISHNAVISM IN COLONIAL BENGAL

Siddhanta Sarasvati published multiple almanacs to spread knowledge about auspicious days in the Gaudiya Vaishnava Community. He aimed to practice Siddhanta Jyotisha, also known as Hindu Astronomy, and emphasized mathematical calculations to determine the exact time, or muhurta, for performing rituals. His efforts not only made devotees aware of the rich culture of the Gaudiya Vaishnavas but also sparked their interest in indigenous scientific traditions. His passion for understanding the cosmic world, coupled with his spiritual wisdom and scientific quest, revitalized interest in his sect, as people had started losing faith in Gaudiya Vaishnavism after Caitanya's death due to the incorporation of outcaste marginalized communities and the introduction of practices such as sexual liberation, which were disapproved by the Vaishnava Gurus. Siddhanta Sarasvati's profound knowledge of Hindu Science made him more acceptable in the Bhadrakalok or gentry society, which sought to experience the core of Hinduism without superstitions. His astronomical journals garnered a substantial number of subscribers all over India, which also served as evidence of his expertise and its utilization to promote Gaudiya Vaishnavism.

9. CONCLUSION

This paper can be considered one of the pioneering works on the development of Astral Science or Astronomy in colonial Bengal. Here we find initiatives taken by a Vaishnava reformer to promote national science or the Indian Knowledge System (Bharatiya Gyan Parampara) in the vernacular. He also facilitated



the creation of a secular national identity based on the indigenous scientific culture and heritage. The translation works from Sanskrit to Bangla on Astronomy by the Bengali *Bhadralok* society perhaps emphasized the importance Vedic traditions and Sanatan Dharma in the lives of the devotees who also wanted to satisfy their quest of spiritual knowledge in the light of scientific rationalism. The flow of knowledge created a significant print culture of scientific narratives and encouraged professional training for aspiring astrologers. This year, on February 29th, the Gaudiya Vaishnava Community celebrated the 150th Birth Anniversary of Siddhanta Sarasvati. My research seeks to commemorate this occasion by placing him alongside other science advocates in colonial Bengal.

NOTES AND REFERENCES

1. Gooptu, Sarvani. (2022). *Knowing Asia, Being Asian. Cosmopolitanism and Nationalism in Bengali Periodicals, 1860-1940*. Routledge.
2. Mitra, Samarпита. (2020). *Periodicals, Readers and the Making of a Modern Literary Culture: Bengal at the Turn of the Twentieth Century*. Brill.
3. Das Gupta, Indrani. (2024). Vernacularizing Science in Colonial Bengal: A Translational Site of ‘Other’ Archives. Published in *LANGUAGE IDEOLOGIES AND THE VERNACULAR IN COLONIAL AND POSTCOLONIAL SOUTH ASIA* edited by Nishat Zaidi and Hans Harder. Routledge.
Strube, J. (2023). (Anti-)Colonialism, religion and science in Bengal from the perspective of global religious history. *Journal of Global History*, 18(1), 88–107. doi:10.1017/S1740022822000110.
5. Dey, Santanu. (2020). Piety in Print: The Vaishnava Periodicals of Colonial Bengal, *The Journal of Hindu Studies*, Volume 13, Issue 1, May 2020, Pages 30–53, <https://doi.org/10.1093/jhs/hiaa003>.
6. Sardella, Ferdinando. (2012). *Modern Hindu Personalism, The History, Life, and Thought of Bhaktisiddhanta Sarasvati*. OUP. *Passim*.
7. Guenzi, Caterina. (2021). *Words of Destiny: Practising Astrology in North India*. SUNY Press.
8. Yadav, Nupurnima. (2022). *ASTROLOGY IN INDIA, A Sociological Inquiry*. Routledge.
9. Kakkar, A. Reassessing European impressions of Indian astronomy (1750–1850). *Indian J Hist. Sci.* 57, 195–201 (2022). <https://doi.org/10.1007/s43539-022-00055-z>
10. Prashant Kumar, S. (2023). The instrumental Brahmin and the “half-caste” computer: Astronomy and colonial rule in Madras, 1791–1835. *History of Science*, 61(3), 308-337. <https://doi.org/10.1177/00732753221090435>
11. Kapoor, R. C. & Orchiston, Wayne. (2023). Colonial astronomy as an element of Empire in British India. *Journal of Astronomical History and Heritage*. Volume: 26, Issue: 1, 113-158. <https://data.isiscb.org/p/isis/citation/CBB770458313>
12. Ibid.
13. Sen, S.N. and Shukla. K.S. (1985) - *History of Astronomy in India*, Indian National Science Academy.
14. Singh, P.B. Rana . (2023) *Cultural Astronomy and Cosmic Order: Sacred Cities of India, Khajuraho, Gaya, Vindhyachal, Varanasi and Chitrakut*. Akshaya Prakashan in association with Indus University.
15. Das, Pavaneshwar . *VEDIC ASTRONOMY OF BHAGAVATA PURANA AND SURYA SIDDHANTA*. Tulsi Books. 2022.
16. Dutt, Bimala Prasad (Bhakti Siddhanta Sarasvati Thakur). *Brihaspati or The Scientific Indian*. Volume 1, Issue 1, 1-8, October, 1896 AD, BS 1306, Month Kartick.



17. Dutt, Bimala Prasad. *Jyotirvid*. Volume 1, First Year, p.2, 1901 AD.
18. *Ibid*.
19. *Brihaspati* or *The Scientific Indian*. Volume 1, Issue 1, pp.1-8, October, 1896 AD, BS 1306, Month *Kartick*. *Passim*.
20. Dutt. Bimala Prasad. *Brihaspati*. Volume 1, Issue 10, p. 244, 462, 1896 AD, BS 1306.
21. *Brihaspati* or *The Scientific Indian*. Volume 1, Issue 1, pp.1-8, October, 1896 AD, BS 1306, Month *Kartick*. *Passim*.
22. Sardella, Ferdinando. (2012). *Modern Hindu Personalism The History, Life, and Thought of Bhaktisiddhanta Sarasvati*. OUP. *Passim*.
23. Dutt. Bimala Prasad. *Brihaspati*. Volume 1, Issue 10, p.473.
24. Dutt. Bimala Prasad. *Jyotirvid*. Volume 1, First Year, see *Purbabhas* (Prelude).
25. Dutt. Bimala Prasad. *Brihaspati*. Volume 1, Issue 10, see *Bibarani* (description).
26. *Jyotirvid*. Volume 2, Second Year, 1902. *Passim*.
27. *Ibid*.
28. *Jyotirvid*. *Pratham*, *Dwitiya*, *Tritiya Barsha O Barsha Trai Puran*. Sri Caitanya Abda 427, see *Bhumika* (Introduction).
29. *Jyotirvid*. Volume 1, First Year, see *Biggyapan* (Advertisement).
30. *Jyotirvid*. Volume 1, Third Year, 1904 AD, 1826 Sakabda, see *Biggyapan* (Advertisement).
31. *Ibid*.
32. *Ibid*.
33. Sardella, Ferdinando. (2012). *Modern Hindu Personalism The History, Life, and Thought of Bhaktisiddhanta Sarasvati*. OUP. *Passim*.
34. Brahamachari, Prangopal (ed). *Nabadwip Panjika*. Mayapur. 2008-09. Gaurabda 522. *Passim*.
35. Dey, Santanu. (2020). Piety in Print: The Vaishnava Periodicals of Colonial Bengal, *The Journal of Hindu Studies*, Volume 13, Issue 1, May 2020, Pages 30–53, <https://doi.org/10.1093/jhs/hiaa003>. See 'Vaishnava practices and rituals'.



THE REVOLUTIONARY ROLE OF ARTIFICIAL INTELLIGENCE IN BANKING SECTOR-A BRIEF REVIEW

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ABSTRACT

Artificial Intelligence(AI) has been adopted in many sectors extensively for future growth and customer satisfaction. The rapid advancement of artificial intelligence is transforming the banking scenario too in India, thus significantly improving the operational efficiency, customer experience, fraud and risk management. AI technologies, include machine learning, natural language processing, and robotic process automation, are being arranged to restructure the various banking operations. Several business organisations use, AI-driven chatbots and virtual assistants to improve customer service by providing round-the-clock support, solving multiple queries, and facilitating transactions. Furthermore, AI algorithms analyse huge amounts of data to offer personalized financial products, improving customer loyalty and satisfaction. In risk management, AI enhances fraud detection and prevention by identifying and distinguishing the usual and unusual patterns in transaction data, thereby safeguarding financial institutions against potential threats. Both the parties, that is, the employees and customers in the banking sector, can be immensely benefited from the execution of artificial intelligence and it can accomplish higher profits, better employee and customer services, engagement and satisfaction. This research paper tries to explore the concept of Artificial Intelligence in Indian Banking Sector, its potential benefits, current applications and its deviations faced by banks along with the future prospect. The transformation from traditional banking operations to AI driven operations will not only redefine the banking procedures, but it would also contribute to a more efficient and accessible banking ecosystem in India. Despite the multi-faceted role of AI and its advantages, the integration of AI in banking faces several challenges, including data privacy issues, regulatory compliance, and the need for substantial investment in technology and training.

KEYWORDS. *Artificial Intelligence; Block Chain; Business Intelligence; Chatbot; Fintech; Machine learning*

1. INTRODUCTION

One of the main sectors contributing to the world economy is the banking area. Banks provide loans, credits (short-term and long term), forex support etc to its customers in its traditional approach. Earlier banks have adopted information technology in its operation by the usage of ATM (Automatic Teller Machine), digital banking which has replaced the huge amount of repetitive and monotonous work by the banking officials. This eventually has enabled the employees to have extra have and utilize the same time for a much complex work at a fast rate with much more precision. The different kinds of IT-enabled tasks are RTGS (Real Time Gross Settlement), EFT (Electronic Fund Transfer), NEFT (National Electronic Funds Transfer), EDI (Electronic Data Interchange), customer relationship management, internet banking, risk assessment, e-learning, core banking solutions, investments, mobile banking, etc.

1.1. Advent of AI in Banking

The banking industry is undergoing a major transformation driven by technological advancements. These advancements have been triggered with the concept of artificial intelligence (AI) which has a revolutionary role in restructuring the traditional banking practices. As banking stands out as one of the strongest component of our world economic domain, it trusts on voluminous amount of data, complex decision-making, and customer communications. The advent of AI offers a unique opportunity to enhance these areas, enabling banks to improve operational efficiency, personalize services, and mitigate risks. AI in banking refers to the application of advanced algorithms and several machine learning (ML) procedures to automate such tasks, analyse the massive data, and enhance the decision-making processes easier, within the financial institutions. AI helps banks and financial institutions to streamline the banking operations, enhance the customer service, assess risk, detect fraudulent transactions and even personalize the financial products. Several AI and ML techniques have been integrated to help banks to gain insights after speculating the massive amounts of data, predict trends and detect risks. This helps to provide an efficient customer service. Thus, AI is renovating the banking industry with smarter operations and providing hassle-free services to the customers.

1.2. Need of AI in Banking

With the penetration of internet usage by more than half a billion in the country, the financial sectors felt an urgent transformation from the traditional services to AI-powered technologies. The reasons are listed below:

- Due to heavy competition in the banking and financial sector.
- Urgent need for process-driven services.
- Personalized customer services at banks.
- Need for operational efficiencies.
- Demanding employee efficiency and increasing productivity.
- Increase the profitability of the banks.
- To reduce hazards and safety risks.
- To collect, cleanse and analyze huge amount of business data
- To reduce fraudulent transactions and bring in effective decision making.

1.3. Importance of AI in Banking

1.3.1. Customer Service Automation

Artificial Intelligence streamlines the banking operations and enhances customer services. Banks nowadays use an automated program called Chatbot and a more advanced type of chatbot termed as virtual assistant. Through virtual assistants and chatbots, customer's queries are handled and solved, making transactions convenient, safe and hassle-free. Round the clock support increases customer's confidence and leads to more investments. Virtual assistants more specifically perform tasks on behalf of the user apart from engaging with the customer. They often utilize AI and ML to improve their functionality on time. AI also analyses huge amounts of customer data for personalized communications. This helps the banks to

understand the preferences and behaviour of the customer and thus create a strong relationship with the customer. Moreover, the AI-enabled tools help in predicting the nature of customer demands. This also enables the banks for efficient resource allocation and optimize staffing so that the service levels are not compromised even at the business peak times. In summary, while both chatbots and virtual assistants facilitate interaction and support, virtual assistants offer broader capabilities, often functioning as personal aides in addition to engaging in conversation thereby improving the business operations.

1.3.2. Fraud Detection and Prevention

By applying different machine learning techniques and advanced algorithms, AI plays an important role in detecting and preventing the fraudulent transactions. By analysing huge volumes of real-time data, the usual and unusual patterns can be distinguished which is a faster way to detect the potential frauds in comparison with the traditional banking methods. As machine learning models learn from new data, adapt to new fraud techniques, assess various kinds of risks, they can predict suspicious activity and give alerts to the customers about the possible danger. This ensures that customers are safe and they can prevent themselves from losses. Additionally, AI-driven analytics can ensure that banks are also safe from financial losses and can safeguard the customer's data and financial assets. Furthermore, through biometric technologies like fingerprint scanning, face recognition system, banks provide an extra layer of security. These enables the customer authentication processes to be strong and ensures that only legitimate users only can gain access to their accounts.

1.3.3. Operational Efficiency

AI remarkably increases the operational efficiency by powering the routine jobs and streamlining the operations. Repetitive functions like data entry, compliance checking, and transaction processing are handled by Robotic Process Automation (RPA). This reduces the workload of the employees and helps them to focus on more complicated jobs that requires human involvement in banks. The AI-driven data helps the employees to make strategic decisions about the customer's behaviour and operational preferences. Thus, banks with the help of AI can achieve greater productivity with efficiency, improve the delivery of the financial products with reduction in operational costs. AI helps the banks to compete with other banks in this digital age.

1.3.4. Investment, Risk Assessment and Management of wealth

Artificial Intelligence plays a significant role in assessing financial risks by providing data and personalized strategies. It captures and analyses huge amount of customer data related to finance, market trends and customer profiles to classify different kinds of risks with a greater accuracy than any other traditional methods. ML techniques can detect the anomalies and help the banks and other financial institutions to assess credit risk and market scenario. Furthermore, AI helps personalized investment options tailored to specific client goals, its risk and other financial adverse situations. Robo-advisors utilize AI to create diversified portfolios, monitor performance, and make real-time adjustments based on market changes, ensuring that investments align with clients' objectives. AI improve the customer interactions by predicting its demands and offer a proactive solution, enhancing overall confidence and satisfaction. By incorporating AI into risk assessment and wealth management, banks and financial institutions can elevate the decision-making process, optimize portfolios, better navigate all the market complexities, and finally deliver the best client value on time.

1.3.5. Regulatory Compliance Monitoring

Regulatory compliance and monitoring in banking are crucial for maintaining the integrity and stability of financial systems. Banks must adhere to numerous guidelines set by governmental and international bodies, such as the Basel Committee, the Financial Action Task Force (FATF), and local regulators. These regulations cover various aspects, including know your customer (KYC) practices, anti-money laundering (AML), capital adequacy, and consumer protection. Effective compliance ensures that banks must operate within the law, reducing the risk of financial crimes and enhancing trust and confidence among customers and investors. It involves the implementation of robust internal controls, regular audits, and continuous employee training. Furthermore, monitoring plays an important role in this framework. It involves ongoing assessment of transactions and business practices to detect irregularities or potential violations in the transactions among the communication parties. Advanced algorithms, such as artificial intelligence and machine learning, are increasingly employed to streamline monitoring processes, enabling banks to analyze vast amounts of data in real time, distinguish between the usual and unusual behaviour patterns. Failure to comply with regulations can result in severe penalties, reputational damage, and loss of customer trust as well as financial loss. Therefore, a proactive approach to regulatory compliance and monitoring is essential for safeguarding the banking sector and ensuring its long-term sustainability. This also helps the banks to remain competitive in this digital age.

The potential benefits of AI in banking and financial institutions, to the employees and customers have been illustrated with a use case diagram in Figure 1. The actors shown here are User/Customer, Bank/Employee and AI system. The different use cases are: personalized services, Chat bots and virtual assistants, Investment & Wealth Management, Risk assessment, Fraud Detection and Regulatory Compliance Monitoring.

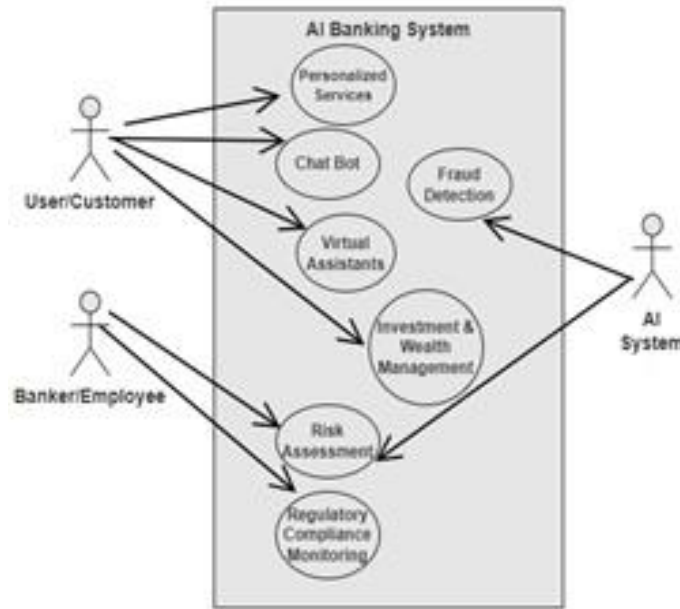


Fig 1. Benefits of AI in Banking

2. LITERATURE SURVEY

Several researchers and authors have found that AI and ML can smoothen the various operations in the banking sector which ultimately enhances customer satisfaction by providing highly personalized financial services.

According to Polireddi (2024) [1], by the help of both AI and ML, banks will be able to handle huge volumes of data collected from clients, manage the transactions, and other sources with unmatched accuracy. It will help the customers to receive unprecedented personalized financial services. Moreover, the techniques applied through AI and ML would also lower the operational cost and prevent against the fraudulent events and hazardous transactions. Donepudi (2017) mentioned that Artificial Intelligence and Machine Intelligence, both offers business solutions in front end and back end processes to enhance customer experience. Traditional banking institutions have shifted towards financial intelligence with the help of Chatbots, virtual assistants to meet their customer's demands. Thus, these help to extend a convenient, safer access and a smarter way to invest money. Thowfeek et al.(2020) in their study ,mentioned that banks which refuse to embrace the computational intelligence will suffer significant losses in terms of market share, cost and also on the time invested.Furthermore,Garg et al.(2022)portrayed the potential benefits, existing applications and also the hindrances faced by Indian banks after implementing AI. They also enunciated that both customers and employees would be enormously benefitted. The fraudulent transactions can be assessed in advance and the overall banking operations could be improved. To combat the ongoing cybercrime, banks are slowly shifting to technoloigoies like analytics and blockchain. On the other hand,Malali & Gopalakrishnan (2020) examined that Fintech companies are filling up the potholes created by the traditional banks.Fintech,driven by AI helps to evaluate credit scores of the users.Thus,AI-assisted technologies would help increase the customers' engagement and satisfaction

and enhance the growth and development of the banks with minimal financial losses. But, Kaya et al. (2019) found and stated that few banks of Europe have introduced AI activities in their banking operations but some are still lagging behind. Banks in USA and China have attracted large investments due to transformation from the traditional activity to AI implementation. Moreover, Fintech (financial Technology) have helped banks to remain competitive. Lestari & Rahmanto (2023) investigated the entry of Fintech into the banking environment by using both primary and secondary data. It concluded that Fintech provides an innovative strategy to compete in the digital age.

Manjaly et al. (2021) depicted that by the usage of both AI and ML, banks have witnessed a revolutionary change. It is neither complicated to learn nor expensive to implement. It has eased the way for the customers to experience a hassle free and safe transaction. Apart from AI and ML, Singh & Pathak (2020). mentioned that a number of AI technologies like NLP (Natural Language Processing), Speech Recognition, Interactive Voice Response System (IVRS), Deep Learning, voluminous amount of data could be collected, cleansed and processed to deliver a smart customer centric system. This AI driven technologies have made the banking processes efficient, convenient, secure and better in many ways. Apart from the potential benefits, Ruby et al. (2020) stated, that an unregulated AI software brings in a lot of difficulties in the banking environment. Rather, if a proactive approach is implemented in the finance sector, then the prospective benefits would ease the way for a better growth of the banks. Agrawal et al. (2024) depicted the revolutionary impact of artificial intelligence in the banking sector and on the customers. Their work stated the current applications of AI and how it brought changes in Indian banks and created a significant impact.

According to Rabbani et al. (2023), AI has significantly transformed customer interactions in banking through the implementation of solutions like chatbots for customer service, which enhanced engagement and satisfaction. This paper further dealt with the various applications of AI like risk assessment, fraud detection, etc. The different AI technologies like predictive analytics, Machine Language and natural language processing helped to gain a competitive edge over the traditional banking operations. But, Sambre et al. (2022) found out that banks in Pakistan could increase their market share if they adopted techniques of AI but awareness among their employees as well as customers were very much essential while carrying out the analysis of data meticulously using SPSS and SmartPLS software.

On the other hand, Umamaheswari & Valarmathi (2023) and Veerla (2021) focussed on the potential merits and the hindrances of AI in the banking environment. Moreover, they even mentioned about fraud prevention and compliance, stronger security, cost reductions and better customer service. Madhura & Panakaje, pointed that the banks will succeed in the digital space if they adopted AI. Subudhi (2019) explored how Indian Banks are implementing the AI technology in various ways - using smarter chat-bots for customer service, personalizing services for individuals, and even placing robots for self-service at their specialized Digital Banking Branches. This has improved the customer satisfaction level and enhanced the growth of the banks. Kaur et al. (2020) too, explored how Artificial Intelligence in finance has brought about a noteworthy change in banks.

Noreen et al. (2023), depicted that the banking industry will be able to make a strategic decision to build and increase the trust among customers with the adoption of AI. This will generate more revenue for the banks and the customers will be able to overcome the risks during the digital transactions. Furthermore, Kochhar et al. (2019) focussed how Artificial Intelligence is helping the banking sector in India to improve risk involved while banking, yield more revenue and also improve the customer satisfaction.



In regard to personalized service automation, Bhattacharya & Sinha (2022) enunciated that multiple usage of chatbots might strengthen the future of Indian banks. Moreover, the banks may even attract more customers and expand their businesses because customers gained more confidence and experienced due to secured, fast and convenient service.

Shetty et al. (2022) used both studied primary and secondary data to study how ICICI bank, Karnataka bank, HDFC bank, etc. implemented AI in their banking processes and to what extent they were benefitted along with their customers.

3. FUTURE TRENDS AND CHALLENGES

Despite of the innumerable advantages that Artificial Intelligence offers, the banking industry do face certain challenges. The biggest challenge is the financial data security and privacy issues. There should also be adequate staff training imparted to cope up with the rapid transformation. Regulatory compliance is another serious concern for the banks. Banks must create a balance between the financial data being used and its laws and regulation after implementing AI. Furthermore, there are few ethical concerns too regarding the use of AI in banking. Too much automated work generates concerns about the future job prospect in the banking sector. Thus, banks should take proactive decisions regarding the skills of the employees and create new job roles and should not replace the workforce due to the adoption of AI.

The future of AI in banking do have positive outcomes. As AI technologies continue to evolve, banking industry experiences increased efficiency and productivity, improved customer experiences, and new financial products leading to gain a competitive edge over traditional services. Thus, the banks attract more customers and help them to invest further. In India, the integration of AI will expedite innovative solutions and reach the undeserved societies too.

4. CONCLUSION

The role of AI in banking is transformative offering multiple opportunities to customers as well as to bankers. It enhances customer satisfaction, streamlines the banking operations, improve investments and lowers the risks with minimal losses. However, this transformation does have some challenges that require careful monitoring and proactive strategies. It should be handled with utmost care and vigilance. There are still many banks in India who have not fully adopted AI. The successful integration of AI will depend on balancing innovation with regulatory compliance and consideration of ethical practices. By the implementation of AI, banking and financial institution will not only restructure their operational frameworks but also create an efficient financial ecosystem. Researchers have carried out their studies in a not so developed area and the same size was small. However, it is noticed that the investments made by the banks are much less in comparison the merits associated with the adoption of AI. The future of AI would be very promising and challenging as the banking sector continues to evolve in the age of computational intelligence. It can also create an efficient defence system for the increasing cyber threats and by introducing to evolving technologies like analytics and blockchain.

REFERENCES

1. Polireddi, N. S. A. (2024). An effective role of artificial intelligence and machine learning in banking sector. Measurement: Sensors, 33, 101135.
2. Donepudi, P. K. (2017). Machine learning and artificial intelligence in banking. Engineering International,



5(2), 83-86.

3. Thowfeek, M. H., Samsudeen, S. N., & Sanjeetha, M. B. F. (2020). Drivers of artificial intelligence in banking service sectors. *Solid State Technology*, 63(5), 6400-6411.
4. Garg, Y. A. S. H. I. K. A., & Sachdeva, K. A. N. I. K. A. (2022). Artificial Intelligence in Indian Banking Sector: A Game Changer. *Dogo Rangsang Research Journal*, 2347-7180.
5. Malali, A. B., & Gopalakrishnan, S. (2020). Application of artificial intelligence and its powered technologies in the indian banking and financial industry: An overview. *IOSR Journal Of Humanities And Social Science*, 25(4), 55-60.
6. Kaya, O., Schilbach, J., & Schneider, S. (2019). Artificial intelligence in banking: A lever for profitability with limited implementation to date. *Deutsche Bank Research*, 1-9.
7. Manjaly, J., Varghese, R. M., & Varughese, P. (2021). Artificial Intelligence in the Banking Sector—A Critical Analysis. *Shanlax International Journal of Management*, 8(S1), 210-216.
8. Singh, T., & Pathak, N. (2020). Emerging role of artificial intelligence in Indian banking sector. *Journal of Critical Reviews*, 7(16), 1370-1373.
9. Truby, J., Brown, R., & Dahdal, A. (2020). Banking on AI: mandating a proactive approach to AI regulation in the financial sector. *Law and Financial Markets Review*, 14(2), 110-120.
10. Agrawal, S. S., Rose, N., & PrabhuSahai, K. (2024). The fintech revolution: AI's role in disrupting traditional banking and financial services. *Decision Making: Applications in Management and Engineering*, 7(1), 243-256.
11. Rabbani, M. R., Lutfi, A., Ashraf, M. A., Nawaz, N., & Ahmad Watto, W. (2023). Role of artificial intelligence in moderating the innovative financial process of the banking sector: a research based on structural equation modeling. *Frontiers in Environmental Science*, 10, 978691.
12. Sambre, K., Joshi, D., & Thapliyal, A. (2022). Analysing the impact of artificial intelligence (AI) in the finance and banking sector.
13. Umamaheswari, S., & Valarmathi, A. (2023). Role of artificial intelligence in the banking sector. *Journal of Survey in Fisheries Sciences*, 10(4S), 2841-2849.
14. Madhura, K., & Panakaje, N. Bank for Tomorrow: Role of an Artificial Intelligence (AI) in Banking Sector.
15. Lestari, D., & Rahmanto, B. T. (2023). Fintech and its challenge for banking sector. *Lestari, D., & Rahmanto, BT (2021). Fintech and Its Challenge for Banking Sector. The Management Journal of BINANIAGA*, 6(01), 55-70.
16. Veerla, V. (2021). To study the impact of Artificial Intelligence as Predictive model in banking sector: Novel approach. *International Journal of Innovative research in Technology*, 7(8), 94-105.
17. Subudhi, S. R. I. H. A. R. I. (2019). Banking on artificial intelligence: Opportunities & challenges for banks in India. *International Journal of Research in Commerce, Economics & Management*, 9(7).
18. Kaur, D. N., Sahdev, S. L., Sharma, D. M., & Siddiqui, L. (2020). Banking 4.0: 'the influence of artificial intelligence on the banking industry & how ai is changing the face of modern day banks'. *International Journal of Management*, 11(6).
19. Noreen, U., Shafique, A., Ahmed, Z., & Ashfaq, M. (2023). Banking 4.0: Artificial intelligence (AI) in banking industry & consumer's perspective. *Sustainability*, 15(4), 3682.
20. Kochhar, K., Purohit, H., & Chutani, R. (2019). The rise of artificial intelligence in banking sector. In *The 5th international conference on educational research and practice (icerp)* (Vol. 127).
21. Bhattacharya, C., & Sinha, M. (2022). The role of artificial intelligence in banking for leveraging customer experience. *Australasian Accounting, Business and Finance Journal*, 16(5), 89-105.



22. Shetty, S. K., Spulbar, C., Birau, R., & Filip, R. D. (2022). Impact of Artificial Intelligence in Banking Sector with Reference to Private Banks in India. *Annals of the University of Craiova, Physics*, 32.



FAKE NEWS DETECTION USING NATURAL LANGUAGE PROCESSING(NLP)

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ABSTRACT

Fake news is false or misleading information presented as news. The prevalence of fake news has increased with the rise of users in social media. Fake news can reduce the impact of real news by competing with it. It also has the potential to undermine trust in serious media coverage. This project aims to develop a method for detecting and classifying fake news stories using Natural Language Processing. The main goal is to identify fake news, which is a classic text classification issue, eradicating the distribution of fake news.

KEYWORDS. LSTM, Vectorization, Embedding, Tokenization, Epoch, Gensim.

1. INTRODUCTION

Since social media is so much prevalent in our world today with no means of control over digital content, our society is always in risk of being exposed to fake news. The effect of fake news can be political, economic, or even personal. Fake news is intentionally written to mislead readers into believing false information. According to research studies, fake news spreads about six times faster than true stories [1]. Over the recent years fake news have gained tremendous proportions on the internet. The high rate of false information being spread like rapid wildfire is highly challenging to deal with. It is very difficult to identify early and confirm its accuracy with a provided appropriate background. Therefore, to address this issue, we are over-viewing the approach in which the task of assessing the truthfulness of the claims in news articles will be done by our fake news detection program.

Past research work was focused on using machine learning and deep learning algorithms to differentiate between fake news and the real ones. Using a dataset obtained from Signal Media and a list of sources from OpenSources.co, Shlok Gilda explored the applications related to NLP techniques to detect deceptive news stories obtained from non-reputable sources by applying term frequency-inverse document frequency (TF-IDF) of bi-grams and probabilistic context free grammar (PCFG) detection to a corpus of about 11,000 articles. He tested the dataset on multiple classification algorithms- support vector machines, stochastic gradient descent, gradient boosting, bounded decision tree, random forests. The test led to find the TF- IDF of bigrams that were fed into stochastic gradient descent model identified non-credible sources with an accuracy of 77.2% with PCFGS having slight effects on recall.

In 2018, Chandra Mouli Madhav Kotteti and Xishuang Dong, managed missing values utilizing data imputation for numerical and categorical features. For sake of categorical features, they imputed the missing values with the most frequent central value in columns while taking numerical features in consideration, a column's mean value was used for imputing the missing numerical values. With the proposed data pre-processing method, the experimental data showed that the MLP classifier is

outperforming baselines and improving prediction accuracy by over 15% than the SGD classifier's accuracy 43.23%. [2].

2. CONCEPTUAL MODEL

Since the approach to detect a fake news can be achieved in many ways and many of the ways have previously been implanted also, a different approach is tried to achieve in this project by the team. The complete concept on how the system is going to work is explained in the following steps:

Step 1: First step is to train our NLP model using the pre-processed dataset.

Step 2: The trained NLP model will generate a classification system using LSTM which in turn will help the user to know whether a given news is fake or not

Step 3: After all the previous steps have been accomplished and a model has been generated, the user just needs to give the Headline or the Body of any news article as input to the system.

Step 4: Then the model will evaluate the given article sample and will give its prediction as the output that whether the article is fake or not.

3. WORKFLOW MODEL

We have planned to complete the task through five steps. And they are explained below:

Step 1: Choose the appropriate fake news dataset.

Step 2: The data is pre-processed.

Step 3: The independent values and the dependent values are extracted and stored. Step 4: Classify the dataset using LSTM. Step 5: Evaluate model performance using metrics.

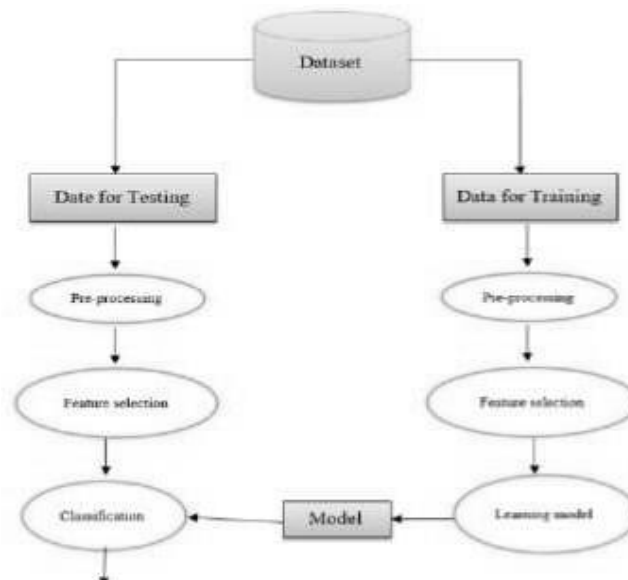


Fig 1. Proposed System

Methodology

4. BASIC MODULES

Fetching Dataset

Although dataset for fake news can be gathered from more than one source like news agency, webpages, or any socialmedia websites, it is not easy to distinguish the news manually.

In this project, the dataset is collected from kaggle.com. We have collected two different datasets for our project. The first dataset contains all the FAKE news. And the other dataset contains TRUE news.

Data cleaning

Data cleaning is the process of fixing or removing incorrect, corrupted, incorrectly formatted, duplicate, or incomplete data within a dataset. When combining multiple data sources, there are many opportunities for data to be duplicated or mislabeled. [3]

In our fake dataset, the data does not contain any publisher information. Publisher information is the information that helps in identifying the source of the news article like Reuters, BBC etc. The publisher information is only present in the true news dataset as they are true values and have the source of the publisher from which they are published. This is used as one of the indicators of a news being fake or not. But some of the values in the true dataset do not contain any publisher information. So, a list is created which contains all the values that do not contain the publisher information. And then a separate column is added into the dataset for publisher information which only contains the source of the news article and if there is none, it is labelled as "Unknown".

It has also been seen that there are certain values that have empty "text" fields, but "title" field is not. The number of such data is calculated, and the "title" and the "text" fields are merged into a single "text" field so that a training model can be generated using LSTM.

Preprocessing the Data

Data preprocessing is the process of transforming raw data into an understandable format. It is also an important step in data mining as we cannot work with raw data. The quality of the data should be checked before applying machine learning or data mining algorithms. [4]

The dataset used in this project does not contain any labels which tells whether the given data value is fake or true. Thus, a separate column, "class", is added into the two dataset and the value assigned to it is '0/1'. Depending on whether it is a fake news or true news respectively the class value is added.

The main columns that are needed for training the model are "text" and "class". So, all the other columns from the two datasets are dropped. As there are two different datasets, "real" and "fake", both cannot be used for training the model, but at the same time both are required. And thus, both the datasets are merged into a new single data set, "data", which now contains both the fake news and true news with only two columns "text" and "class". As shown in Figure 8.

As it can be seen in the Figure 8, the text data contains many special characters which needs to be removed. For removing all the special characters from the data, a single package is used from GitHub. The advantage of using this package is that it removes all the special characters with the help of a single function call. The package can be found at the link below:
https://github.com/laxmimerit/preprocess_kgptalkie.git.

Vectorization

Before a machine learning model can be generated and trained based on some data, the data needs to be converted to some sort of numerical data (vectors). Vectorization is the process of converting an algorithm from operating on a single value at a time to operating on a set of values (vector) at one time. Although there are many ways of vectorizing a data, in this project the technique used is known as Word2Vec technique. [5]

Word2Vec

Word representations in Vector Space founded by Tomas Mikolov and a group of a research team from Google developed this model in 2013. Most of the NLP systems treat words as atomic units. There is a limitation of the existing systems that there is no notion of similarity between words. Also, the system works for small, simpler and outperforms on less data which is only a few billions of data or less. In order to train with a larger dataset with complex models, the modern techniques use a neural network architecture to train complex data models and outperforms for huge datasets with billions of words and with millions of words vocabulary. This technique helps to measure the quality of the resulting vector representations. This works with similar words that tend to close with words that can have multiple degrees of similarity. After training, word2vec models can be used to map each word to a vector of typically several hundred elements, which represent that word's relation to other words. This vector is the neural network's hidden layer. Word2vec relies on either skip-grams or continuous bag of words (CBOW) to create neural word embedding [6]. Gensim is one the library in Python that has some of the awesome features required for text processing and Natural Language Processing [7].

Creating and Training the Model

Tokenizing the input text

Now that the text data is converted into vectors, there are two ways to train the machine learning model. One method that can be used is to directly feed the vectors into the model and the other one is to feed the vectors as an initial weight into the machine learning model, then it recreates the vectors.

For the sake of better accuracy, the method that has been chosen is to feed the weighted vectors into the ML model. To do so, Tokenizer Class has been used. This class is for vectorizing texts, or/and turning texts into sequences.

Converting text into corresponding index values

Since the input value is stored in 'X', X is passed into the method which in turn converts the text data into a set of sequence, by the "text to sequences ()" method, and not like vectors. This means that for a particular word a sequence number is assigned.

Padding up the sequence

After analyzing the data from the given histogram, it is found that most of the news articles have less than 1000 words in them. Thus, news articles having more than 1000 words, the extra words are truncated. And if the number of words is less than 1000, 0's is padded. This means that length of each sequence is made to be 1000.

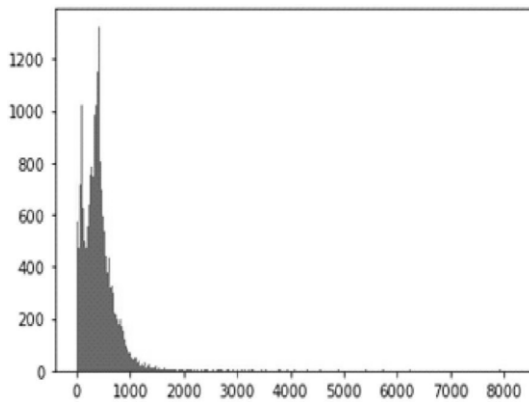


Fig 2. Sequence padding

Getting the Weight Matrix

Now, the weight matrix is created with the help of the tokens, each of being the size of 100.

The Model Structure

The model used is Sequential. Sequential model is appropriate for a plain stack of layers where each layer has exactly one input tensor and one output tensor. And since our model has only one input, i.e., the news article and only one output, i.e., Fake/True, Sequential model is used.

The Machine Learning Algorithm that has been used is a Neural Network since neural networks is the best suited model for Deep Learning in Language Processing. A sequential model consisting of Embedding, LSTM (Long Short-Term Memory) and Dense Layers have been used. Embedding Layer and returns a single value from a single neuron Dense Layer. The activation function used for the dense layers is "Sigmoid". The model was trained for 6 epochs.

Model Summary

After the model is successfully created, the last thing that remains to be done is to fit the model into the train data and evaluate the test data.

Fitting the Test and Train Data into the model:

```
X_train, X_test, Y_train, Y_test = train_test_split(X, y)
model.fit(X_train, Y_train, validation_split=0.3, epochs=6)
```

In the given snippet, validation_split=0.3 means that 30% of the data is used for validation. Epoch means training the neural network with all the training data for one cycle. In an epoch, we use all the data exactly once. A forward pass and a backward pass together are counted as one pass: An epoch is made up of one or more batches, where we use a part of the dataset to train the neural network [8]. Here 6 such cycles have been used. More the epoch, more will be the fitting. But it should be kept in mind that too many epochs may result into overfitting of data.

5. MODEL EFFICIENCY

The accuracy of the model is checked. Here accuracy score() method which is the most frequently utilized measure metric. The accuracy score method is used to calculate the accuracy of either the fraction or count of correct prediction in Python Scikit learn. Mathematically it represents the ratio of the sum of true positives and true negatives out of all the predictions.

$$\text{Accuracy} = \frac{\text{TP} + \text{TN}}{\text{TP} + \text{T} + \text{FP} + \text{F}}$$

Where,

TP – (True Positive) Number of records which is correctly classified.

TN – (True Negative) Number of the correct rejection records.

FP – (False Positive) Number of incorrect records.

FN – (False Negative) Number of incorrect rejections.

In multilevel classification, the function returns the subset accuracy. If the whole set of predicted labels for the sample accurately matches with the true set of labels, then the accuracy of the subset is 1.0 otherwise, its accuracy is almost 0.0 [9]. The accuracy score of the model trained is found to be 98.7%.

Results obtained.

Although the accuracy score is 98%, but still when testing with real world data sometimes the prediction result may be different. The following table show some of the test inputs given.

6. LIMITATIONS OF THE SYSTEM

- The news articles present in the dataset are old which results in wrong predictions sometimes.
- The webapp is deployed on Heroku Platform which is a free hosting platform and have some issues related to page loading time, size of the file to be deployed must be within 500 Mb and hence requires high compression.
- Also, when high volume of inputs is given, the webapp tends to crash some times.
- Since the model is based on a single classification system, accuracy becomes much less as compared to models that are built on multi- classification techniques.
- Since the model uses gensim library for vectorization, many issues are faced while installing gensim library.

Sl. No	News Text	Predicted Results	Correct
1	Covishield, Covaxin Prices Cut To ₹ 225 Day Before Booster Drive Begins	FALSE	Yes
2	Tens of thousands marched on beleaguered Sri Lankan President	TRUE	Yes
3	21-year-old Indian student shot dead at subway station's entrance in Canada's Toronto The victim Kartik Vasudev, who was enrolled in its	FALSE	NO
4	Twitter handle of Uttar Pradesh CM's Office hacked for near	FALSE	NO
5	Twitter handle of Uttar Pradesh CM's Office hacked for near	TRUE	Yes
6	Infosys, TCS, Wipro Q4 results preview: Wage hikes may impact IT firms' margins; check top stock picks Indian IT firms including TCS, Infosys, Wipro and others	TRUE	Yes
7	Bengaluru civic body bans animal slaughter, sale of meat on Ram Navami In its order, the civic body said that meat shops and	TRUE	Yes
8	Delhi, Haryana, Punjab, Himachal Pradesh on Alert from April 9-12 As Severe Heatwaves Maintain Grip over North	TRUE	Yes
9	Donald Trump says Obama was a Liar Punjab, Himachal Pradesh on Alert from April 9-12 As Severe Heatwaves	FALSE	Yes
10	Maryam Nawaz calls Imran Khan 'psychopath', asks him to	FALSE	Yes
11	Karnataka Minister KS Eshwarappa To Quit Amid Row Over	TRUE	Yes
12	All About Coronavirus XE Variant as COVID-19 Cases Rise in Delhi-NCR The World Health Organisation (WHO) had last week	TRUE	Yes
13	Known for his riches and his rifts, Gujarat Congress leader Indranil Rajyaguru now goes to AAP The son of Congress leader Sarjay Rajyaguru, Indranil had	TRUE	Yes
14	'PM Sangrahalaya will become...' PM Modi dedicates museum to India's premiers The Pradhanmantri Sangrahalaya is a museum dedicated to	TRUE	Yes
15	Watch MS Dhoni's last-minute field change scripts Virat Kohli	FALSE	NO

7. FUTURE SCOPE

- The system can be implemented using multi-classification techniques for better results.
- A mechanism can be added which automatically trains the model with current news and saves it.
- Certain modifications are required to use this model with news that are present in the social media sites.
- It can be deployed on a paid server which does not require compression of the actual file. And also, that the system does not crash when dealing with high volume of inputs.

8. CONCLUSION

Most of the research work described in this paper was done using Keras library of Python and many other research papers published related to Fake News Detection. The final model, with a validation accuracy of 98.7 % performs quite well on most circumstances.

REFERENCES

1. Reham Jehad Al-Shammari and Suhad A "Yousif Fake News Classification Using Random Forest and Decision Tree (J48)" December 2020.
2. Rampersad G, Althiyabi T 2020 "Fake news: Acceptance by demographics



and culture on social media” J. Inf.Technol. Politics 2020, 17, 1–11.

3. Guide To Data Cleaning: Definition, Benefits, Components, And How To Clean Your Data, [https://www.geeksforgeeks.org/data-preprocessing-in-data-mining/](https://www.tableau.com/learn/articles/what-is-data-cleaning#:~:text=Data%20cleaning%20is%20the%20process,to%20be%20duplicated%20or%20mislabel; Last accessed on 14 April 2022.4. Data Preprocessing in Data Mining, <a href=) . Last accessed on 14 April 2022.
5. What is Vectorization in Machine Learning? By Jalal Mansoori, <https://towardsdatascience.com/what-is-vectorization-in-machine-learning-6c7be3e4440a>, Last Accessed on 14 April 2022.
6. word2vec, <https://www.tensorflow.org/tutorials/text/word2vec> , Last Accessed on 14 April 2022.
7. GENSIM 4.2.0, <https://pypi.org/project/gensim/>. Last Accessed on 14 April 2022.
8. Difference Between a Batch and an Epoch in a Neural Network, <https://machinelearningmastery.com/difference-between-a-batch-and-an-epoch/> last accessed on 14 April 2022.

THE FOLK TRADITION- THE LAUR-CHANDA, MADHU MALATI KATHA ETC.

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Chaurapanchasika Style + Indo-Persian Categories: Combination of Indigenous Indian & Persian Stylistic Characteristics: Regional Variations of Western Indian Painting:

Traditional and submerged folk styles have always played an important role in the development of „Classical „-Indian art at different periods. **The folk traditions actually emerged with and through the various regional variations of the Western Indian painting** . This important style of illustration, practiced during the early sixteenth century reflects elements from both the **Chaurapanchasika style along with the Indo Persian categories**. This late –variety of pre-Mughal, mediaeval, manuscript - tradition, **combined both the indigenous Indian and Persian stylistic characteristics**. The indigenous features always dominated the format and style, due to the involvement of professional native artisans of the bourgeois, non-classical milieu.

Vast Output of Jain Manuscripts During the Rule of provincial Sultanates: Direct Sultanate Commissions, Jnana Bhandars & Appearance of Shahi Figures:

(There had been a vast output of Jain Mss. during the rule of the provincial Sultanates of Gujarat, Malwa and Jaunpur . Interestingly **these had indigenous features and were directly commissioned by the provincial Sultanate courts**. The numerous illustrations in the collections of the **old and flourishing Jnanabhandaras of Rajasthan, Saurashtra and Gujarat** are immensely helpful in precisely tracing the emergence of miniature art in the fifteenth and sixteenth centuries. It is quite important to note the **overwhelming impact of Persian painting of the Turkoman and other schools frankly apparent in the appearance of the Shahi figures** which were probable influences or borrowings from the entourage, fashions and regalia of the contemporary Sultanate courts.)

Pre-Mughal Hindu provincial Folk Styles: Hindu Popular Folk Traditions: Derivative Qualities from Classical Idioms:

Significantly and quite interestingly, **the Hindu popular folk traditions of painting in the pre-Mughal Sultanate period ,had played a very helpful and inspiring role in the evolution of early Mughal painting** .There can hardly be any doubt about the fact that the Indian provincial folk –styles had from times immemorial possessed a **rustic boldness** which was **full of plasticity and rich lively colour schemes** possessing inherently a wide variety of religio-mythological repertoire of motifs and designs , derived from post-Ajanta wall painting , contemporary sculpture and various forms of provincial semi-tribal art which probably can never be strictly defined with absolute certainty, but which must have surely existed from times immemorial.

Characteristics of Hindu Popular Folk painting: Martial, Feudal, Erotic & Romantic Appetite:

Popular -folk painting was in fact a reflection of the martial , feudal and erotic tradition of the various warrior chiefs and their romantic appetite for all material pleasures which quite naturally throbbed with glowing colour and innovative design , recounting tales and ballads of chivalry and love .In order to appreciating the state of popular folk art in the pre-Mughal period , **the popular Avadhi romances like the Chandayana/LaurChanda , Madhu-Malati Katha , Mirgavat of Qutban , the Chhitai –Varta , and others like the erotic , -Kokasastra , the epical and religious ,Aranyaka Parvan (A.D. 1516) and the Bhagavata miniatures** are very helpful and interesting .

Popular Avadhi Romances: Chandayana/Laur Chanda , Madhu Malati Katha , Mirgavat of Qutban , Chhitai –Varta , KokaShastra , Aranyaka Parvan (A.D. 1516), Bhagavata Miniatures ,late 14th c. Kalpasutra-Kalakacharya katha -1416 Kalakacharya Ms. , Vasanta Vilasa of 1451 :

The late fourteenth century Kalpasutra-Kalakacharya katha Ms. in the prince of Wales Museum Bombay along with illustrated scroll of the Vasanta-Vilasa , written in 1451 A.D. at Ahmadabad are all very important and **significant for understanding the growth of this new style** . Besides the Kalakacharya Ms. dated 1416 A.D. is the most important pictorial document in this perspective as its illustrations are highly suggestive of the beginning of the Rajasthani conventions of later days.

The Laur-Chanda –Chaura Panchasika Group: Gita Govinda Fragments, Ragamala Folios , 1540 Mahapurana Ms. –“Chakdar Jama”:

But it is mainly the Laur-Chanda Chaura-Panchasika group , which includes manuscripts and isolated folios of a large variety in various collections , Indian and foreign which are worth examining .In this regard **the Laur-Chanda Ms. in the John Rhylands Library , Manchester along with the Gita-Govinda fragments in the Prince Of Wales Museum , Bombay and the Ragamala folios in the Vijayendra Suri Collection** are worth noting .The **Mahapurana manuscript in the Sri Digambara Jaina –Atisaya Ksetra , Jaipur , painted in 1540 A.D at Palam , near Delhi is of the greatest significance , as it was painted during the early years of the Mughal period.** Moreover, the depiction of the typical „five-pointed –jama” (Chakdar-jama) in some of the manuscripts, so conspicuous in the Hamzanama and other early –Akbari manuscripts, is very interesting and helpful in understand the development of early-Mughal painting.

Palace Painting /Wall Paintings; Laur Chanda , Mirgavat of Qutban , Chhitai Varta :

The „Laur-Chanda –the lovestory of Laur and Chanda also furnishes a beautiful description of wall-painting or „palace-painting”. The subjects were mainly the epical heroes and villains , episodes and inhabitants of the semi-mythical animal world as well as petty local ballads and stories .The „**Mirgavat of Qutban**” written in the beginning of the sixteenth century , gives almost the same information about painting as the LaurChanda , but **also including the dalliances and miracles of Krishna and his gopies along with other curious stories** and rows of animals and birds as decorative devices or border designs .In the „**Chhitai-Varta**” dealing with the story of „Ala-ud-din and Chhitai” , daughter of Ramadeva Yadava , whose early versions appear in the fifteenth century , an elaborate description of wall-painting is given . Apart from the „Epics the paintings also included „**eighty-four**” „**erotic postures**” from the „**Kokasastra**” , scenes of dancing and hunting.

Ramayana & Mahabharata, Supasanahachariyam Ms., Jaisalmerni –Chitra Samridhi , 1516 Aranyaka Parvan , 1413 Jain Ms.:

Scenes from the Ramayana and the Mahabharata and the love episodes of Krishna, folk tales, scenes of love-making, dancers, musicians and animals formed favourite subjects, but **subjective convention was never the hurdle**. The illustrated Aranyaka Parvan , dated A.D. 1516 , shows that the Mahabharata was a favourite subject of the illustrators . The episodes of Ramas life are depicted in the Mirgavat, and the Bhagavata miniatures depict incidents from Krishnas life. Apart from the popular Jain manuscripts the

Supasanahachariyam manuscript of 1413 A.D. in the Atmananda Jnanabhandara Collection at Baroda along with the painted bookcover from Jaisalmer, depicting the incidents from the life of Mahavira , i.e. the Jaisalmerni –Chitra-Samridhi , may also be included within this group .

Advent of provincial Sultans Patrons of Persian Culture; Foreign Influences Welcomed, Discovery of New –Innovative Forms & Ideas:

In many examples, **the prevailing mood is that of a gay abandon** not to be met with in the hieratic productions of the fifteenth century. **The movement is free and unsophisticated.** But with the advent of the „Provincial- Sultans“, patronizing Persian culture and literature, a movement, slow and hesitant at first, discovered new forms and ideas which accepted and even welcomed foreign influences, and a new chapter thus came to be added to the history of Indian painting.

New Era of Collaboration, Cooperation & Interrelative Influences ; -Indian Inspiratrion for Early Akbari Atelier:

Actually all these manuscript illustrations contributed largely towards the evolution of the pre-Mughal Rajasthani painting styles and also acted as an Indian inspiration in influencing the Persianized art of the Early-Akbari atelier. Popular folk tales and subjects like the „Krishna-legend, the Ragamala or forinstance the popular tales of Laur-Chanda, Chaura-panchasika , Mirgavat , etc ,opened up new avenues of ideas to the artists and a new artistic era of collaboration , cooperation and interrelative influences and bold experiments began under the patronage of the provincial-Sultanates .

Demand For Painting After Islamic Conquest: Patronage: Provincial Sultans + Rich Jain Buisnessmen :

Even though the steady demand from manuscript painting had fallen after the Islamic conquest, there is reason to believe that a number of indigenous artists and craftsmen, must have continued their vocations. A large number of those numerous decorators and skilled illuminators must have also been employed by the provincial Sultans for „palacedecoration while the less fortunate ones found solace and patronage under the rich Jain merchants, bankers and traders.

Era of Secular Compromise, Understanding & Reconciliation; Role of Sufis & Evolution of Avadhi Mathnavi , Dialect of Hindi & Mullah Daud:

Thus an era of understanding and reconciliation had begun between Hinduism and Islam. The role of the Sufi saints in evolving a new form of expression in Avadhi , a dialect of Hindi , the language of the common people was remarkable in this respect .Though based on Persian socio-religious narratives , called Mathnavis , these also possessed quite a mystic strain . Thus during the finishing years of the 14th century, a new trend in Hindi literature was witnessed. It is difficult to strictly ascertain the exact date as to when this form of dialect or writing (Avadhi-Mathnavi) started, though it is evident that by the closing years of the 14th century, the work entitled the –„Chandayana“ or the LaurChanda, an extensively narrative poem in Avadhi by Mulla Daud became popular.

Juna Shah-Firuz Shah“s Dewan : Mulla Daud & Chandayana Praised By Badauni :

Historically what is far more important and rather significant to note is the fact that the real patron of this romance was Juna Shah –Khan-I-Jahan who happened to be, Sultan Firuz Shah Tughluq“s Dewan Again, Mulla Daud the man who composed this narrative poem, based on the Avadhi romance in the year 1377/1379-80 A.D., was a native from Dalmau,(61 miles from Kanpur in Uttarpradesh)and happened to be a Sufi disciple of the mystic saint Jainuddin . Significantly Maulana Daud and his work has thus been greatly applauded by the Akbari historian Badauni in his Muntakhab-ut-Tawarikh

Shirazi /Turkoman In Spirit & Form: Indian In Style: Accomplished Art Practice, Process of evolution, Influence of Shiraz /Turkoman Painting -1500 A.D.; Stylistic Process of Indianization

The 64 illustrations of the Chandayana along with 4 illustrations of the Mainasat manuscripts, give evidence of an accomplished art practice which had had undergone a process of evolution. Moreover though in spirit and form the Chandayana series were influenced by the Shiraz or Turkoman painting

of A.D. 1500 they had been quite naturally and rather significantly been subjected to a process of Indianisation in style. The overall effect is however one of great beauty as revealed by the colours employed, the delicate brush work and richness of arabesques in gold, black or red and of course the sensitive or rather emotional draughtsmanship and lightness of the atmospheric effects.

Pre-Mughal To Mughal Passage & Extension of Painting traditions: 1525-1550/1570: Chakdar Jama:

The illustrations moreover represent a particular type of pre-Mughal painting tradition, prevalent in Northern India and extending even to the Mughal period. The art historian Moti Chandra feels that this manuscript is important because it was being illustrated just before the advent of the Mughal rule in India i.e. 1525 A.D. But Karl Khandalavala prefers a time period from A.D. 1525 to about 1570 A.D., thus providing a possible solution to the much hyped and popular but pending problem of the Chakdar jama. Though he feels that on stylistic grounds the manuscript should be dated between A.D. 1525 and A.D. 1550, he has extended the possibility of the time period to about 1570 A.D., because of the presence of the „Chakdar –jama“.

Singular Pre-Mughal Hindu Ms: Popular Islamic Bourgeois Art:

Thus on stylistic grounds the manuscript is of a very high historical importance as it is the only manuscript of the pre-Mughal stylistic type. Again it appears that the Rylands Library manuscript was the product of a court atelier, somewhat similar to the Prince of Wales manuscript.

Influence of Persian Heritage: Clouds, Arabesques, Flora & Fauna Landscape & Trees Individual Style Fostered At Jaunpur :

Interestingly though many a Persian element are visible in the Prince of Wales Museum manuscript, these foreign elements have been greatly and remarkably Indianized. It is quite probable that this manuscript represents an individual style fostered at Jaunpur or perhaps some other Northern Indian provincial court. The cloud forms represented are peculiarly characteristic of Persian painting of the late 15th and the 1st half of the 16th centuries. Moreover, the influence of Persian heritage is visible in the exquisitely drawn arabesques and the flora and fauna particularly in the landscape and tree types.

Compositional Features: Derivatives from Ancient Indian Traditions: Innovations /Changes;

On the other hand the compositional features show clear derivatives from the ancient Indian tradition as evident in the division of the picture space into two or more panels like the relief sculptures of Buddhist-Hindu narrative art of the ancient period. Again there are miniatures covering the entire picture space without any panel-wise format or division. Again both the male and the female types are of a definite Indian character. The frequent use of the yellow complexion has been clearly derived from the Western Indian or Gujarati tradition. Infact both the female and male facial types were derivations from Western Indian or Gujarati tradition. The new innovations or changes are evident in the absence of the farther projecting eye in the female facial types. There is also a certain change in the facial appearance as the large staring eyes appear to be considerably modified. Moreover the male facial types appear to be more carefully finished inspite of being derived from the Western Indian or Gujarati painting.

Influence of provincial Persian & Sultanate architecture & Motifs:

The surface of the painting was divided into three or more panels and the multicoloured backgrounds appear. The traditionally Hindu and favourite background colour of „Lacquer-red“ is conspicuous by its absence. The influence of provincial Persian painting is apparent in colour and tonalities employed. The new type of background was enriched with patterns like tufts of grass painted in gold, small flowering plants and the „comma“ patterns employed. A new fondness for the Blue and Pink tile decoration appeared due to the same Persian influence. On the other hand, the recurring motif of the pillared and cusped arches, frequently coloured yellow with arabesques all over them appear due to the visual influence of the contemporary Sultanate architecture of the provincial courts. This influence

is also apparent in the appearance of Peacocks with spread out tails and pitchers on stands and „Surahis“.

Male & Female Costume: Realism, Animals & Birds:

There is noticed a tendency to treat the animals and birds in a realistic manner. There appears thus a certain degree of pleasing realism in the illustrations. The architecture is shown as consisting domes, decorations, arabesques and scrolls characteristic of Lodi architecture. In certain cases, there rated with tiles. The characteristic of the male costume is very interesting and important. the male costume consists of a kulahadar latticed pagri which is significantly a distinctive feature of the male costume in the Chaurapanchasika group of paintings, long and short jamas , both of the Chakdar style and the round (gherdar) style , Pyjamas (Salwar) , Kamarband , tunic , Dupatta and shoes

Costume: 4/6 Pointed Jamas: Dying Influence of Western Indian /Gujarati style, Different Colours, Extensive Use of Gold & Arabesques:

The jamas are of several types; either round or with straight ends or chakdar type with four pointed and six pointed ends. The Islamic influence is also felt over the female costume as evident from the odhani made of transparent material, and the tight sleeved choli and also the coloured and patterned material. At the same time the (dying influence) almost extinct influence of the Western Indian , Gujarati style is seen in the depiction of the odhani fanning out stiffly from the body , and the pointed breasts .Again the feature of the body resting on the farther end of the cushion or carpet , continued in the paintings of Rajasthan .The colour scheme employed is very different from the conventional colours used in the Western Indian or Gujarati illustrations and an entirely different tonality of colours are pleasantly blended together .An extensive use of Gold and arabesque patterns have been used with great delicacy and effect .It appears that the artists delighted in painting arabesque patterns with unsurpassed skill . The tonality of colours is absolutely different from the conventional colours used in the Western Indian miniatures.

Arabesque & Gold Designs; Calligraphy & A Distinctive Style, „The Artists“:

(The mannerism of painting arabesque patterns is pursued with much fineness of the brushwork and the artists delighted in painting the arabesque patterns extensively along with the effective and delicate use of Gold in decorative details .)Calligraphy of a high order showing aristocratic refinement of skill and technique has been used in the text on the reverse .The laur-Chanda artists were thus competent painters , familiar with the fusion of the Indian , Persian and Turkoman elements , creating a distinctive style .They thus represent the most refined achievement of the pre-Mughal painting , incomparable in delicacy with the Manchester Laur-Chanda and the Ni“mat Nama .

Influence & Contribution To Mughal Painting:

A subtle and successful combination of colour schemes , architecture , textile and elements of Persian painting helped the painter in attaining a wonderful and new impression ,which again was accentuated by the elements of the background and landscape executed in accordance with the different events of the story line .**Besides the newly evolved features like the dramatic effect created by the depiction of the expressive hand gestures and the creation of vigorous men and graceful women , gave a fresh direction to Indian painting , helping in the creation of the Mughal style and further development and progress .**However the static motifs , poses , figures and costumes along with the incidents and decorative motifs are repeated endlessly in a rather monotonous manner . The decorative motifs appear rather limited in character and the ethnic types appear without much variation.

Laur-Chanda of Rylands Library:

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On the whole it cannot be denied that the brilliance of the illustrations of the LaurChanda series mark the evolution and discovery of a new and innovative style within the entire range /repertoire of Northern Indian painting exerting considerable influence upon the forthcoming construction and development of the „early-Mughal style“ of book illustration , under Akbar“s patronage .However there is a dearth of material for historically (chronologically)understanding the development and evolution of this new stylistic trend . Inspite of this scarcity and unavailability of material, the Laur-Chanda manuscript in the collection of the Rylands Library, Manchester is a source of undoubted major importance as it shows a certain continuity of the tradition of the Prince of Wales Museum Laur-Chanda in a somewhat diluted form.

There is however a difference of opinion about the date of the two manuscripts, i.e. the Rylands Library manuscript and the manuscript of the Prince of Wales Museum as a period of 25 years at the most separates the manuscripts from each other .Moreover though the Persian influence is observed in both the manuscripts yet it is more vividly and rather expressively marked in the Prince of Wales version of the Laur-Chanda .

The characteristic features of the Rylands Library manuscript (Illustrations) are worth noting in this respect. The figure types of this manuscript are as seen clearly based on the prince of Wales Museum Laur-Chanda illustrations. A general progress towards a more naturalistic depiction is evident as the angularities are rather toned down and the conventional sandalwood and yellow complexions eliminated and even the slightly exaggerated chest , a remnant of the Western Indian Gujarati tradition disappears .the traditional moustache is discarded and the characteristic side whiskers appear

Female Figures: Marked Developments :

A marked degree of development is noticeable in the female figures of the Rylands Library manuscript .While the survival of the Western Indian or Gujarati tradition is quite evident in the female figures of the Prince of Wales Museum Laur-Chanda , the female figures of the Rylands Library manuscript illustrations, inspite of bearing a close relationship with their counterparts (the female figures) in the Prince of Wales manuscript ,definitely exhibit certain points of departure , converging towards the early Rajasthani types .Moreover the compartmentalization of the story into one or more frames, not only helped the artist in narrating the whole story but also remind us of the ancient Indian technique of narrative art as known from the narrative reliefs of Bharhut , Bodh Gaya and Sanchi , Amaravati and other places .

Perspective: Persian Origin :

Absence of Chinese Clouds & Arabesques ; Turkoman Trees & leaves ; Western Indian Cattle , Persian elephant ; New feature In Architecture , Persian Turkoman Painting of The 15th c.:

Again the idea /notion of the perspective is suggested by the depiction of a „mound „ in the background, while the monotony of the plain surface is often relieved by the flowering shrubs, „commas“ and the „tufts of wiry grass“. Interestingly what is noteworthy here is the fact that all of these afore mentioned motifs (mound, flowering shrubs, commas and tufts of wiry grass) are of Persian origin .The Chinese clouds , arabesques along with the dramatic sky , seen in the Laur-Chanda manuscript of the Prince of Wales Museum is absent here .Interestingly though the treatment of the landscape conforms to a similar treatment of nature in the „early-Rajasthani“ paintings , the characteristics of drawing the trees with their leaves and branches is reminiscent of the Turkoman style .Again while these patterns were derived from the Persian-Shirazi or Turkoman painting , the representation the cattle is absolutely similar to those seen in the Western Indian miniatures , though a realistic sence of mobility had been infused in some of the animals . The elephants represented in the illustrations are of an unfamiliar type and were actually inspired by the elephants represented in Persian painting , particularly those in the Turkoman school of the late 15th century , seen by the

Indian artists and craftspeople. The architecture is suggestive and simple being reduced to the minimum and an interestingly new feature / characteristic is the „Pink brick-work with red joints“ and „the wall brackets with tassels“.

Features of Male & Female Costume; Male Turbans; Long & Short Type Jamas : The characteristics of the Male and the female costume are very interesting and significant. As far as the male costume is concerned two types of Turbans make their appearance. One is of the trellised Kulahdar type and the other the flat type largely similar to the ones seen in the Jaunpur Kalpasutra of A.D. 1465. The short type of the Chakdar –jama, though seen in the illustrations of the Sultanate period –Hamza nama, become very rare in their appearance in the paintings of the early-Mughal period in general. Interestingly both the short and the long types are well depicted in this manuscript of the Laur-Chanda

Female Costume: Characteristics: Assimilative trends In Textile Design & Printing ; Triangular Odhani Ends –Stiff –Western Indian Static Mannerism :

The notable characteristics of the female costume is constituted by the depiction of both colored and patterned material indicating the assimilative trends prevalent during the Sultanate period in the textile designs and in printing. On the other hand the depiction of the triangular ends of the „odhani“ standing out stiffly is in fact a reminder of the still existent mediaeval mannerism of the traditional and largely static Western Indian school of painting. Though the Manchester Laur-chanda has only a few short-comings, it is no doubt inferior to the Laur-Chanda manuscript of the prince of Wales Museum in skill and elegance. Actually the illustrations of the Manchester Laur-Chanda not only constitute an important document of Indian painting of the pre-Mughal period, they may also be considered a treasure house for the study of contemporary life and manners in all its varied phases.

Lahore & Chandigarh Museum Laur –Chanda :

The Laur-Chanda manuscript of the Lahore and Chandigarh Museums represents a popular love epic of the 16th century and has, most probably the same date and provenance as the Chaurapanchasika illustrations. The provenance is the same Northern belt from Delhi to Jaunpur, Uttar Pradesh in general as supported by the two well-known and dated manuscripts, one from Agra (1516 A.D.) and the Delhi (1540 A.D.) area. In the illustrations of this Laur-Chanda manuscript, the human figures very largely resemble those seen in the Chaurapanchasika illustrations. Significantly, the exaggerated treatment of the chest shows the survival of the Western Indian or Gujarati tradition, though in a comparatively less pronounced manner. Even the female figures appear similar to those represented in the Chaurapanchasika illustrations.

A difference is however noticed in the treatment of the eye. While in the Chaurapanchasika series the eyes are found to be extended nearly to the ears, they are padol-shaped and comparatively much less in length. **Besides the gestures of the hands are more expressive than those represented in the Chaurapanchasika series.** Therefore in spite of the near approximation and many other similarities, with the female figures of the Chaurapanchasika group, **an unprecedented enhancement of the aesthetic qualities along with an endeavour towards attaining a classical refinement and naturalism is observable in the treatment of the hand, its gestures and even in the padol-shaped eyes.** Apart from this, **the depiction of full figure reveals an attempt at imparting three dimensional modelling**, while the narrow waist follows the traditional, classical Indian, female –aesthetics. The exaggerated treatment of the male chest, the pointed moustache, sharp nose and chin along with the pointed ones in the case of the female figures, however reveal the last vestiges of the Western Indian or Gujarati tradition.

**Lotus Flower & Buds : Classical & Ancient Indian Connections & Lineages ;
Continuance of Ajantan & Elloran Traditions Into The /As Design Motifs /Border
Decorations,,In The Early Mediaeval & Pre-Mughal Manuscript Illustrations :Bilateral
Intercourse & Interactive Absorption ; Intersecting Bud Design-Ancient Brahmanical & Semi
Religious Patterns –Gupta Idiom –Pala & Jaina Mss.**

The depiction of the Lotus flower and buds again reveal the ancient connections and lineages of the Ajantan and Elloran traditions descending into the art of the early – mediaeval and pre-Mughal ,India. Following the traditional method of narrative art , the vertical picture compositions are divided into compartments numbering 2 to 4 , each carrying a section of the story .The wide floral bands decorating the foreground are indicative of carpets and floor spreads ,also candidly expressing the bilateral- intercourse and interactive absorption of the artistic repertoires between the Hindu and Islamic pictorial traditions , designs and motifs .As stated earlier , the uncommon design of the intersecting lotus bud , also visible in the illustrations of the Chaurapanchasika series , act as the frank reminders of the ancient Brahmanical and Buddhist semireligious patterns , carried down by the Gupta idiom into the traditions of the Pala and Jaina manuscript illustrations of Eastern and Western India .

**Ancient Associations: Lotus, Fish , Aquatic Birds : Traditional Reincarnation of Ancient
Narrative Reliefs –Continuance of Brahmanical & Buddhist Art :**

The noticeable association of water with the lotuses , fish and aquatic birds is again a traditional reincarnation of the ancient Brahmanical and Buddhist narrative reliefs seen in rock-cut caves , monasteries and constructed temples and further reveals the conscious and sub-conscious continuance of these ancient motifs in all the historical phases of Indian art , i.e. Ajanta ,Ellora , Bagh , Pala , Jaina , Sultanate , Mughal , Rajput and even as late as the Punjab –Hills .

**Continuity of Pre-Islamic Devices & Motifs In Late Akbari Illustrations : Night Scenes ;
Manner of Treatment :**

Again the manner of treatment of the night scenes , by drawing white dots on the dark background , representing a starlit night , is a typical pre-Islamic and mediaeval Indian device , which made its first appearance in the Bharat Kala Bhavan , Laur-Chanda illustrations , but which again continued uninterruptedly in the late Akbari and post Akbari paintings , not to mention the miniature illustrations executed under the patronage of the 4 Deccani Sultanates . Even the rope-like , white serpentine was adopted at random by the Mughal and Rajasthani miniaturists .

**Realism & naturalism : Birds & Animals (In Sultanate & Early Mughal Illustrations): Horses
With Trappings & Armour , Dappled & Piebald Horses :**

Moreover the crows and the peacocks are executed in a realistic manner and their naturalistic treatment is clearly visible .The Horses , furnished with trappings and armour , show the Persian influence and are full of life , being treated in vigorous and spirited manner . The traditional Jain (Gujarati) manner of representing the dappled or piebald horses with series of dots /spots all over their body was continued without any modification in this manuscript whatsoever .This feature or device was again a much earlier Western Indian adaptation , inspired by Persian prototypes .

**Architecture & Indoor Paraphernalia : Direct Influence of Indo Islamic Sultanate Indoor Décor
_Adapted By Early Akbari Artists :**

As far as the architecture is concerned, there is hardly any imposing depiction, except a pavilion with a squat Lodi style dome, merlon and eaves. Again almost all the pavilions are accompanied with the „bandanwars“ or „decorative fringes trimmed with beads and tassels“, which was a very common feature visible in the 16th century painting. Very often the „Chauris“ are seen to be suspended from them, while the floor is furnished with carpets, revealing the direct influence of the Indo-Islamic (Sultanate) indoor décor. In certain chambers, beds, chests, ewers and water-pots have been depicted as the necessary furnishings. These very furnishings are again interestingly noticeable in the illustrations of the „Early-Akbari“ period, particularly in the Hamza-Nama, the Akbar Nama, the Babur Nama and the Tuti Nama, ultimately becoming an indispensable and integral accompaniment of the Mughal interior, such as the bedrooms and the living apartments.

Assimilation of Mediaeval Hindu & Sultanate Fashions; Coexistence & Intermingling: Continuity of Male & Female Costume Types In Mughal Illustrations; “Wimple /Odhani”:

As far as the male and female costumes were concerned it is quite interesting to appreciate the depiction of the „Chakdar-jama, both short and long along with trousers (Salwars), continuing into the Mughal miniatures, showing the assimilation of the mediaeval Hindu and Sultanate fashions, which of course had coexisted and intermingled earlier. More interesting is perhaps the manner of drawing the wimple, veil or „Odhani“ behind the head, stiffly standing out and reminiscent of the tradition of Jain manuscript paintings of Western India, primarily the Gujarati illustrated manuscripts. Besides a definite attempt at enlarging the scope of the composition is visible resulting in the representation of a large number of participants. A certain coordination or bringing together of the several episodes of the same incident is seen. The figure types in these illustrations are distinguished by a sense of animation, avoiding doll-like figure – treatment seen in earlier manuscripts. The composition and expositions are quite convincing and the colours have been applied with an air of effective simplicity. More importantly these illustrated leaves actually reveal the continuity of a distorted classical tradition within the limits of a bourgeois art and marking a definite advance on the Aranyaka parvan illustrations of A.D. 1540. These illustrations may have also played some part in the development of the fully mature / developed Rajasthani school, which again is not beyond controversy. The illustrations of this manuscript however fall within the limits of the Chaurapanchasika group as they follow the same conventions and style, in spite of the signs of definite advancement. Moreover in order to avoid confusion and help in easy comprehension and elucidation, each episode belonging to the same incident was contained within a separate register besides the proper utilization of the spaces gestures and expressive movements which were being effected.

Historical, Social & Artistic Importance of Mirgavat Of Bharat Kala Bhavan :

The historical importance of the Mirgavat manuscript in the Bharat Kala Bhavan, Banaras, (written by Qutban in A.D. 1504 in the reign of Hussain Shah Sharqi), is of great significance because the refuge of the Sultan of Jaunpur, i.e. Hussain Shah Sharqi, at Kahalgaon in Bengal might have in some way or the other influenced the prevalent tradition of manuscript illustration in Bengal under the Hussain Shahi Sultanate. In the illustrations of this manuscript it appears that the painter had had an abundant opportunity to deal with various aspects of the contemporary scenario. The artistic expression employed by the painter is laconic and it depends (verging) more on folk art, in which stress was laid on simplification. Unlike the painter of the Laur-Chanda, that of the Mirgavat is unaccomplished in providing interesting information on the social and cultural life of the people.

Vigorous Folk Painting School of Jaunpur : Kayastha Painters of Bihar & Eastern Uttar Pradesh Significantly, the Mirgavat illustrations indicate and inform us about the existence of a vigorous school of folk painting probably centered at Jaunpur, the capital (former capital) of Sultan

Hussain Shah Sharqi .The provenance was undoubtedly that of Eastern Uttar Pradesh or Bihar , as the „Kaithi“ script , acursory variant of Nagari , was until recently being used by the Kayasthas of Bihar and Eastern Uttar Pradesh . Again quite interestingly as the Kayasthas were also painters, they inturn might also have illustrated this manuscript.

Resemblances With & Differences With The Aranyaka Parvan of A.D. 1516:

There are 250 full page illustrations in this manuscript of the Mirgavat , preserved in the Bharat kala Bhavan . It appears that these illustrations must have been executed much after A.D. 1504 , when the romance was being written . As there are certain resemblances between some of the physical types depicted in the illustrations of this manuscript and those seen in the Aranyaka Parvan of A.D. 1516 , it may be possible to contend that it was equally quite early in date and provenance .At the same time there are wide differences between the two manuscripts and though the Chakdar-jama is constantly seen in the illustrations of this manuscript, the question of a final solution of the date will always depend on whether it can at all be considered earlier or later than the Chaurapanchasika series .

Folk Style & Influence of Ancient Indian Narrative Art :Illustrations In A Folk Style ; Panels Representing Parts of The Event :

Actually , when compared with the superior of the Kulahdar group , the illustrations of this manuscript appear to be executed in a folk style , a general situation or circumstance , worth considering , while attempting to date the popular style of this ,manuscript .The composition is extremely simple and is accommodated in one or two panels , each panel representing a part of the incident , showing in turn the influence of the ancient Indian narrative art .

The Monochrome Background & Monotony Relieved ; Indicative of Mobility ; Stances & gestures Indicative of Action & Emotional Stress;Red Colour & Large Flowers-Influence of ancient Brahmanical & Jaina Ritualistic Influence :

The monochrome background uses dull red, green, yellow and brown , and the monotony is relieved by a liberal use of red blotches and sometimes by the large flowers hanging down from the top . Again this very device of using the red colour and large flowers hanging down from the top , shows the influence of ancient Brahmanical and Jaina ritualistic and artistic influence .The characters appearing in the paintings vary from one to four and are aligned in a row . What is however more important and significant is the fact that the stances and gestures of the characters indicate action and emotional stress, which again is indicative of mobility . And it is this mobility that is indicative of advancement and development . it also reminds us of the lively and sensitive character of ancient Indian plastic art as evident in the cave –frescoes .

Plain Bands Indicative of refined & Narrative Continuity ; Signs of Attempted

Development :Body Colour Following Western Indian Gujarati Tradition; Only Particular Physical Parts With Angular Draughtsmanship ; Sense of Mobility /Action Minimizing Weakness In Drawing .Advancement &Development :

Moreover the bands separating the panels are not decorative as in the prince of wales Museum Laur-Chanda , but plain indicating an attempt at refinement and narrative continuity . On the other hand the body colour is either yellow or brown , distinctly following the Western Indian or Gujarati tradition , surviving in the illustrations of the Chaurapanchasika group .Besides though the angular draughtsmanship is favoured ,it has only been resorted to , while emphasizing certain parts of the body .Though the drawing of hands and feet is rather weak , yet the effects of this weakness had been sizably minimized by the sense of mobility or action .

The Symbolism of Imparting Special & Exalted Importance ;Lively & Sensitive

Character –Ancient Indian Plastic Art ;Royal Men of Exalted Status , Shown Larger Than The Rest, As Seen /Witnessed In Ajanta Murals & Early Indian Plastic Art ;Joyous & Sportive Attitudes of Women Expressive of Mobility & Liveliness ; - Folk & Popular Character of The art Form : Comparatively Robust Women Lacking Feminine Elegance .

In general the human figures are of medium height , but royal men of position and honour have been depicted as comparatively taller than the rest . This method intended by the illustrator to emphasize the comparative importance of these distinct personae , is quite common to the many schools of „early-Indian painting“ , having its earliest appearance in the Buddhist murals of Ajanta and the plastic art of the ancient and mediaeval India .Thus the symbolism of imparting „special/exalted- importance“ , persisted in Indian art even during the Sultanate period as evident in these hybrid –folk illustrations .The mobility and liveliness expressed in the joyous and sportive attitudes of the women clearly reveal the folk and popular character of this art form . Though the female figures are comparatively much more robust than those represented in the other manuscripts of the Chaurapanchasika group , they lack the womanly elegance and refinement witnessed in the illustrations showing women , in the Lahore Museum , Laur-Chanda and the other illustrated manuscripts of the Chaurapanchasika series .

Chaurapanchasika Type male Costume Types ; Characteristic Fashion of Wearing The Dagger ; Adoption By The Mughals ; Characteristic Fashion of wearing The Dagger :

The costume of the male figures is characteristic of the Chaurapanchasika type .The men are shown wearing the long Gherdar jama , long and short Chakdar- jama , the Kulahdar turban , „Dupatta“ and narrow „Kamarband“ to which a dagger is attached . This characteristic fashion of wearing the dagger was carried down / adapted into the martially royal and fashionable etiquettes of the early Mughal and Rajasthani visual aesthetics , culture and representational art .The kings are however shown wearing the „Mukuta“ , a typically Hindu-Jain characteristic , while the jama is shown as made of plain and flowered material .

Female Costume „In General „ Following The Palam Mahapurana of 1540 ; Influence From Contemporary Sultanate Courts ; Sultanate Decorative Motifs :

The female costume however is largely similar to that witnessed in the Palam Mahapurana , dated 1540 A.D. The „odhani of the women however lacks the elegance and sophistication of the ones represented in the Chaurapanchasika and the Laur-Chanda illustrations of the Lahore Museum .It should also be noted that the „Odhani“ in the Mirgavat is not made of thin Muslin, but is usually of the heavy patterned material – a type showing in turn, the negligible impact of Sultanate - cultural influence as far as the material of the costume was concerned . But the decorative motifs employed show some signs of the influence from the contemporary Sultanate courts in the form of lines , dots , stars , rosettes , chains , fish-scales and much more .The half-sleeved choli and the accompanying skirt are however made of the heavy patterned material .

Profound Persistence of The Hindu Folk Influence : Chaurapanchasika Ornaments(Circular Disc & peg Like) ; Prevalent Contemporary Fashions of Uttar Pradesh Region ;Traditional Representation of Water :

The profound persistence of the Hindu-Jain –folk influence on the ornaments is evident from the heavily decorated ornaments with pompons . The women are thus shown wearing a circular disc in one ear and the peg –like ear –ring ,characteristic of the Chaurapanchasika type . The presence of this type in this manuscript , perhaps reveals the prevalent fashion in a particular part of the country , in this case most probably Uttar Pradesh . The horizon is executed with extreme simplicity and the

landscape is largely suggestive on the other hand the water is represented by its natural association with the fish and the lotus flowers and also in the traditional basket pattern. Some times it is also symbolized by meandering lines running parallel to each other.

Idealized & Traditionally Conceived Animals (The Animal World) ; Simplified Lodi Architecture –Architecture With Lodi Squat Domes & Turrets ; Largely Contemporary MSS.: Mirgavat Illustrations ; Aranyaka Parvan Illustrations -1516 ; Mahapurana Ms. Illustrations ; 1540 A.D.

The animal world is treated in the traditionally conceived and beautifully idealized manner. For instance the tiger and the wolf retain their Western Indian characteristics and the camel is of a peculiar lanky type. On the other hand the horses are treated realistically. It is significant to note that the elephant is no longer of the awkward type, following a provincial Persian tradition, as seen in the Manchester Laur-Chanda manuscripts. The architecture is simple, mainly consisting of a pavilion with squat Lodi period domes, turrets and bed-rooms. It is thus quite evident from these characteristic features that the Mirgavat illustrations can be easily compared with the illustrations of the Aranyaka parvan of A.D. 1516 and the Mahapurana manuscript dated A.D. 1540 and are largely contemporaneous.

Similarities In Ethnic Types & Other elements Like costume In Both The Mirgavat & Aranyaka Parvan : Similarities In Poses ; Compositional Features & Modes of Expression :

Not only are the ethnic types similar in these manuscripts but there are other similarities as well. At times the figures appearing in the Aranyaka Parvan have counterparts in the Mirgavat. Such a comparison however becomes evident from the available evidence. For instance, in an illustration representing Mirgavat and her lover Rajakumara, the figure of Mirgavat is similar to that of the lady in blue skirt in the Aranyaka Parvan. Apart from this particular instance, there are other instances like the similarities in the costumes, worn by the men and the women in both these manuscripts in spite of the absence of the Chakdar jama in the Aranyaka parvan. Besides all these similarities a familiar likeness is also witnessed in the similarity of poses, compositional features, modes of expression, the use of Pompons which are easily visible as the common features of both the manuscripts.

Illustrated For Middle Class People : Aranyaka Parvan of A.D. 1516 ; Mahapurana Ms. of A.D. 1540 & The Bharat Kala Bhavan Mirgavat ; Attainment of Religious Merit & Satisfaction of Artistic & Sexual Urge For Artistic & Romantic Sensuality –Eroticism & /Visual Pornographic Delight :

Actually the Aranyaka Parvan manuscript dated A.D. 1516 and the Mahapurana manuscript dated A.D. 1540 along with the Mirgavat in the Bharat kala Bhavan, all belong to a class of manuscripts which were illustrated for the middle class people.

Again these middle class clients, wanted to possess these manuscripts either for attaining religious merit, as witnessed in the Aranyaka parvan and the Mahapurana manuscripts, or for satisfying their natural cravings for romantic sensuality and fondness for dramatic eroticism, amply revealed by the text and illustrations of the Avadhi poems like the Chandayana and the Mirgavat.

Middle Class Bibliophiles & Popular Mediocre Folk Painters ; Growth of A New Tradition Among Bourgeois Classes :

These middle-class bibliophiles were not essentially very affluent patrons and thus they were not in a position to spend sizeable amounts of money on the production of these illustrated manuscripts. Therefore they had endeavoured to satisfy their religious and artistic urge and love for art, by employing popular folk painters of the mediocre strature and milieu. Nonetheless, quite significantly, such works prove that in the 16th century, after the development of the Western Indian or Gujarati school, a new variant and a new tradition grew up among the bourgeois classes of the Jain, Hindu and Muslim communities (middle-class), who patronized art by commissioning illustrated manuscripts of the popular order.

It is also very important to note that all the three manuscripts, namely the Aranyaka Parvan of A.D. 1516, the Mahapurana of A.D. 1540 and the Mirgavat were extensively illustrated, each consisting of over 250 illustrations. And it is this very enormity in the number of illustrated folios/leaves that indicated, that book illustration on a pretty large scale was being practiced, inspite of the fact that it was a bourgeois type of production, favoured by the middle class and produced by the subaltern classes of folk craftsmen and artists. Thus the reasons behind the evolution of the Chaurapanchasika group ultimately lay in the artistic background and situation created by the emergence of the provincial Sultanate courts and their patronage for Indo-Persian / Perso-Islamic book illustration.

**The Art of The Sultanate Courts Vs. Art patronized By The Middle Class
Bourgeois;- The Growth of New Tastes & Religious Individualism; Evolution of The
Chaurapanchasika Group As Indicated By the Aranyaka Parvan of 1516 –The Date For The
Beginning of The Chaurapanchasika Style:**

Actually the Sultanate courts primarily continued with their individual and respective admiration for Persian book illustration which they heartily commissioned. But to the middle-class Bourgeois people belonging to the Jain, Hindu and Indo-Muslim communities, the traditions, styles and standards of Persian book illustration and production were largely unknown. Thus they (the middle-class)evinced a new taste for the illustration of manuscripts and books, containing their chosen matter and it was this very growth of new taste and religious individualism that brought the whole

Chaurapanchasika group came into being. In fact the very date of the Aranyaka parvan, i.e. 1516 may be taken as indicating the time for this new development.

**Commencement : Closing years of The 15th C. ; The New Developments In Indian Painting : Ist
Decade of the 16th C. ; The Classical Phase of The Chaurapanchasika Group ; i.e. the
Aranyaka Parvan „The Mahapurqana & The Mirgavat Mss.**

This new development in Indian painting occurred before the first decade of the 16th century and commenced in all probability in the closing years of the 15th century. Again the question of the total absence of any evidence of a classical -phase prior to A.D. 1516 is significant, but no definite opinion can be expressed on this point. It is not known as to whether there was any classical phase from which the manuscript illustrations of the Aranyaka Parvan, the Mahapurana and the Mirgavat were derived, perhaps there was the subconscious memory of the ancient Brahmanical artistic tradition and practical training of the artisans which carried on the last vestiges / hereditary canons of the lost „Ajanta-Gupta“ classical idiom.

**The Classical Ajanta Tradition Not Dead But Alive In The Plastic Creations & Adornments of
Temples :**

The long lost tradition of classical Ajanta , though almost extinct in the painted manuscripts was altogether dead in the plastic creations and adornments of the temples , which definitely influenced this phase of mediaeval Indian painting in some way or the other . However , all of this artistic hypothesis cannot be proved by strict and defining examples , for which of course a further study on this particular aspect is very much needed .

The Extent of The Influence of The Chaurapanchasika Style on Mughal Painting :[Ajantan Influence –Ancient Murals ; Flora & Fauna ; broken Down Motifs & Symbols]:

It can only be strongly assumed , as to what degree , this so-called „new-tradition“ evolved by the Laur-Chanda –Chaurapanchasika group of paintings continued in the later periods and moreover the extent to which , they could influence the development of Mughal painting under Emperor Akbar .Perhaps this tradition continued as an archaic survival in some provinces almost till the beginning of the 17th century . The influence of Ajanta on the general plasticity and figure drawing was no doubt enormous , but in other respects excepting the flora and fauna the influence of ancient Indian mural tradition was maintained only through broken down motifs and symbols .

Continuity: Tuti Nama & Hamza Nama : Chaurapanchasika Style ; Tradition Absorbed By Akbars National Atelier ; Names of the Concerned Scholars

It is however definite and certain that with the coming into being of Akbar’s great atelier , the traditions evolved by the Chaurapanchasika group very soon lost their identity , their independent existence being absorbed , along with the other provincial styles by the great national atelier established under Akbar’s guardianship .The illustrations of a certain Tuti Nama in the Cleveland Museum of Arts clearly indicated the happenings in the formative period of Mughal painting under Akbar .

The Tuti Nama & The Hotly Debated Issue : Aesthetic Controversy :Formative Happenings Evident In The Tuti Nama Manuscript Illustrations –The Beginnings /Or Priory Phase of Artistic & Aesthetic Absorption ; Karl Khandalavala & Basil Gray ; Sherman Lee-1560-68 ; Styles : Chaurapanchasika Motifs & Types :Not A Homogeneous Style ; Moti Chandra’s Views ;

But again this is a hotly debated issue , giving rise to much aesthetic controversy as both Khandalavala and Basil gray regards the Tuti nama of the Cleveland Museum of Arts as a production , not earlier than c. A.D. 1580 whereas Sherman Lee believes that the manuscript was prepared from 1560 to 1568 A.D. Moreover and quite interestingly the text of this manuscript was independently translated from the Sanskrit , „Sukasaptati“ (Seventy Tales of a Parrot) into Persian by Nakhshabi and completed in the year 1330 A.D. It is further important to notice that the style in some of the miniatures , among the total 211 illustrations , are clearly suggestive of the motifs and types observed in the Chaurapanchasika series of illustrations .The style is however not homogenous as the illustrations were executed over a ,long period of time and might have surely involved the process of adaptation ,deduction and assimilation in accordance with the availability of artists and the nature of the imperial patronage . Dr. Moti Chandra however feels that the miniatures were largely executed in the early Akbar style of the Hamza Nama.

Male Figures : Greater Receptants / Retainers ; Survival of Few Characteristic Features of Laur –Chanda & Chaurapanchasika style In Few Tuti Nama Illustrations :Characteristics of female Costume:

In a few of the miniatures of the Tuti Nama in the Cleveland Museum of Arts , the survival of a few characteristics features of the Laur-Chanda –Chaurapanchasika illustrations are visible .Interestingly these characteristics are observed in a greater measure in the male figures as compared to the female ones . Even in the representation of the costume and ornaments these old mediaeval traits are noticeable . The odhani in some of the miniatures though made of transparent muslin , does not possess the static geometrical and sharp triangular proportion of the early Jain palm leaf illustrations . But the ghagra/lehenga (skirt) is largely similar to that seen in the Chaurapanchasika illustrations and designs on the cloth such as the stars , chequers and rosettes , also imitate the same familiar design and form . Even the earrings are similar to the peg and rosette shaped ones seen in the Laur-Chanda-Chaurapanchasika illustrations .This however indicates the provincial folk and popular character of the illustrations .A continuity of the older Hindu-jain tradition is also witnessed in the tassels decorating the heavy ornaments

**The Male Costume & Survivals ; Admixture / Amalgam & Advancements ;
Landscape & Architectural Depictions; Amalgam of the Old& new styles; Advancement In
Compositions: The Character of the Horizon & the Clouds In The Tuti Nama :**

The male costume consists of the „atpati“ type pagri and the various varieties of the Chakdar jama which are very common . The Kulahadar turban , quite prevalent during the Lodi times was going out of fashion even in the provinces . This fashion however survived in the provinces bleakly after dying out in the early Mughal court. The survival of the Laur-Chanda – Chaurapanchasika tradition is however strongest in the depiction of landscape and architecture .The flat treatment of the architecture reveals a rather strange amalgam of the old and new styles . The pavilions on the other hand are similar to the ones seen in the Laur –Chanda of the prince of Wales Museum. Even the character of the horizon and clouds in the Tuti Nama illustrations appear to have been imitated or adopted by the painters from the Prince of Wales Laur-Chanda manuscript .A certain advance is also noticed in the composition , which was not divided into compartments , much like the illustrations of the Laur-Chanda manuscript in the Prince of Wales Museum .

**Tutinama; Amazing Amalgam of Archaic & New Rules & Traditional Styles :
Strongest Survivals & Continuities of Laur –Chanda –Chaurapanchasika – Depiction of
Landscape &Architecture : The Tuti Nama ; The Creation /Or Product of A Provincial Court /
Workshop-Existing Quite Some Time After The Establishment of Akbars Studio:**

The Tuti Nama manuscript is thus a curious blend of the old and new conventions and traditional -styles.According to a few scholars , this manuscript marks the beginning of the Mughal school .On the other hand others opine that this kind of experiment was not unusual in the setting of a provincial court or workshop , existing much after the establishment of the early Mughal style of the Hamza Nama.

**SURVIVALS/ OR CONTINUITIES: THE SURVIVALS OF LAUR –CHANDA –
CHAURAPANCHASIKA –STYLISTIC CULTURE ON MSS.**

The Malwa Idiom of Bundelkhand & The Laur –Chanda –Chaurapanchasika Style of The Northern Belt From U.P. To Delhi : The Survival of The Chaurapanchasika Style In The Malwa Idiom; Malwa Idiom Alike The Chaurapanchasika Style :

The survival of the Chaurapanchasika style is seen to a certain extent in the so called Malwa idiom of Rajasthani painting. The so-called Malwa –Idiom is moreover in general a rajasthani school in ethos , draughtsmanship, variety of pigmentation , composition and motifs .(5).It is not impossible that the Malwa artists settled down in Bundelkhand , which later on came to be known as the state of Narsinghgarh. These very painters and craftsmen might have also undertaken commissions and might have sold out their productions throughout Bundelkhand and Rajasthan at large .

Curious Mixture of Western Indian & Laur –Chanda –C.P.S. Tradition: The 4 illustrations of The Parsvanatha Vivalahu ; The Kulahdar Turban Still In Fashion ; A.D. 1576 . :

Thus the four illustrations of the Parsvanatha Vivahalu (the marriage of Parsvanatha) , datable to A.D. 1576(forming a part of the Jain text of Ratan Sar in the Boston Museum) exhibits a curious mixture of the Western Indian /Gujarati and the Laur-Chanda – Chaurapanchasika traditions .Interestingly it appears from these illustrations that the turban of the Kulahdar variety was still in fashion even as late as A.D. 1576 , the date when these illustrations were being prepared . Again it is quite possible that this turban type might have been represented due to an attempt intended at repeating the LaurChanda –chaurapanchasika stylistic tradition .A clear trace of this stylistic tradition is visible in the figure of Prabhavati , mainly in the rather emotional , refined artistic skill and a few niceties of the drapery and apparel .

The Sangrahani Sutra ; Survival of Laur Chanda-Chaurapanchasika Stylistic Culture – Decadent & Disarrayed tradition Absorbed By The Akbarid Atelier :

Another illustrated manuscript , that of the Sangrahani Sutra , in the Muni Punyavijayaji Collection of Ahmedabad shows the survival of the Laur-Chanda – Chaurapanchasika stylistic culture . Actually this old tradition appears to have been in a state of decay and disarray and it was in this stage of its disintegration , that it was sought to be inducted and was moreover absorbed by the Akbarid atelier , leaving vestiges in a few illustrations of the Rajasthani schools .

An Early Ragamala ; Survival of the C.P.S. Style : 1575 In The Stages of Quick Absorption : Quick Absorption Into the Mughal Atelier :

An early ragamala set in shows the survivals of the Chaurapanchasika style, though it cannot be denied that the style of this, manuscript was to a great extent influenced by the Mughal style of the Akbari period . Interestingly it is quite apparent from the paintings of this manuscript that the Laur-Chanda

Chaurapanchasika tradition was in the process of being quickly absorbed in order to evolve an innovative style of illustration. This particular illustrated manuscript appears to have been prepared after A.D. 1575 and can at best be ascribed to the last quarter of the 16th century. Thus it appears that by the last quarter of the 16th century i.e. after about 1575 A.D., the Chaurapanchasika tradition was quickly being inducted into the Mughal atelier in order to evolve a new national and visual expression for the entire Akbarid Hindustan .

The Uttaradhyana Sutra of 1591 A.D: Induction & Absorption of Few Mughal Characteristics ; Inspiration From Older Schools –Reminiscent of the Laur-Chanda –C.P.S. Tradition :[Characteristics]

In a similar manner the Uttaradhyana Sutra dated A.D. 1591, clearly indicates the survival of the older tradition in its illustrations. Though the style of this illustrated manuscript reflects the induction and absorption of a few Mughal characteristics, there are features which show the inspirations from older schools, reminiscent of the Laur-Chanda Chaurapanchasika tradition. These characteristics are visible in the manner of depicting the architecture, the facial angularities, the trees represented in a spray like design and the typical features of the decorative textile.

DERIVATIVE SURVIVALS:

Derivative Survivals of the Fast Disintegrating Chaurapanchasika Style:

In most of these illustrated manuscripts the horizontal format is visible and the background is mostly in the monochrome accommodating, the suggestive architecture and vegetation which helps to provide space from the usual dullness. More over the sharp angularities of the technique along with the manneristic male and female features, with their exaggerated –hairy chests, moustache in the recurved fashion, traditionally drawn round breasts along with the characteristic female apparel and the brown and yellow complexion clearly show the derivative- survivals of the fast disintegrating - Chaurapanchasika style.

Two Gita-Govinda Illustrations: National Museum –GitaGovinda Illustrations of prince of Wales Museum; Common Origin In Female Figures; Modification & Advancements:

The survival of the Chaurapanchasika tradition is also evident in the two Gita Govinda illustrations of the National Museum, which depict features quite akin to the Gita Govinda illustrations of the prince of Wales Museum. Interestingly a common origin is noticed in the female figures of both these manuscripts, though the female figures of the National Museum illustration exhibit an aesthetically fulfilling and refined development. **A modification of the basic /general characteristics of the LaurChanda Chaurapanchasika tradition is however noticed in the manner of putting on the wimple or „odhani“.** According to Karl Khandalavala the human figures exhibit a steady evolution /advancement from the Laur-Chanda –Chaurapanchasika tradition, as a result of the impact from the early Mughal school, which in turn was influenced greatly by the same style.

Modifications of & Advancement from: Laur Chanda –C.P.S. Tradition: Early Rajasthani Miniatures Produced in the Area from Delhi & U.P.; Influence of Mughal Painting on The Northern belt i.e. Delhi to U.P.(„Chawand“):

According to Karl Khandalavala, just as the Rajasthani school is considered to be an outcome of the Mughal stylistic impact on the Western Indian or Gujarati tradition, the paintings of the Northern belt from Delhi to Uttar Pradesh was also influenced by Mughal painting in the second half of the 16th century. Certain early Rajasthani miniatures may have been the products of the area from Delhi to Uttar Pradesh, i.e. the Northern Belt. In this context it is worth mentioning that the

Chawand Ragamala set also depicts the survivals of the Laur-Chanda – Chaurapanchasika tradition at Chawand, the fugitive asylum of Rana Pratap after Udaipur, between 1578 and 1605.

Ragamala & The Survivals of Laur-Chanda –C.P.S. Tradition; Distinct Exaggeration in Female Features; Minor Similarities/Characteristics Resemblances: Male Figures –Chawand & Laur

Chanda Series: Traditional & Marked Angular Sharpness; Angularity In The Treatment of The „Chadar“ or „Odhani“; Geometric Alignment of Clothing (Few Items) –Old Western Indian Gujarati Tradition

Interestingly the illustrations of this Ragamala show the much evolved and refined (developed) features of Rajasthani painting, but at the same time exhibits a few characteristics which might have surely borrowed or absorbed from the LaurChanda –Chaurapanchasika series. The male figures of the Chawand illustrations display a few characteristic features, quite akin to the males appearing in the LaurChanda series . The female features show the traditional and marked angular sharpness which are much more exaggerated in this Ragamala set quite distinct from the usual female types represented in the Laur-Chanda-Chaurapanchasika series of illustrations., The older tradition of the Western Indian Gujarati tradition is evident in the angularity in the treatment of the „chadar“ or „odhani“ and an almost geometric alignment of some items of clothing.

„Pasanahacariu“: relation Between The Western Indian & The Chaurapanchasika Style (C.P.S.) : Association With the Common People : Expression To The Beliefs , Emotions & Socio –Religious Observances of The Masses :

In the recent years a 15th century Jain manuscript from Gujarat, the „Pasanahacariu“ has forced historians to seriously think about the Chaurapanchasika style. This illustrated manuscript actually heighlights the relationship between the Western Indian style of painting and the Chaurapanchasika style .This is actually a term which is used to denote an unspecified group or class of manuscripts, such as the Aranyaka –Parvan of A.D. 1516 in the Asiatic Society , Bombay , the Mahapurana manuscript of A.D. 1540 in the Digambara Bada Mandir , Jaipur , the Candayana manuscript , divided between the Lahore and the Candigarh Mudeums , the dispersed , Bhagavata – Purana , a folio of the Bhagavata –Purana in the Collection of Madhuri Desai , the French Ragamal folio in the Victoria and Albert Museum, London, the Vijaysuri Ragamala , the Mirgavata manuscript in the Bharat Kala Bhavan , Banaras , the Gita – Govinda in the prince of Wales Museum , Bombay and lastly the AdiPurana .

The C.P.S. Mss. ; Unspecified group /Class –Illustrated At Rupanagar Delhi – Tomar Rajput Rule ,Tomars of Gwalior –Babur“s Visit To The Gwalior Fort ;

Evidence of The Solitary Illustrated Pre-Mughal Painting Tradition At Gwalior:

The Pasanahacariu manuscript preserved in the grantha-bhandara of the Shantinatha Shvetambara Jain temple in Rupnagar (Delhi) , is very important because it was illustrated at Gwalior during the rule of the Tomar Rajputs who also ruled Delhi , before the Mughals . The importance and significance of Gwalior as a centre is very strategic because it was visited by the Mughal emperor Babur also. The illustrations of this manuscript are moreover important due to the fact that they constitute the only recorded evidence of miniature painting at Gwalior before the evolution of the Mughal style of illustration at Agra .

The Basis For The Emergence of the Chaurapanchasika Style:

The Pasanahacariu Ms. Illustrations; The Mandu Kalpasutra of A.D. 1439 ; The Jaunpur Kalpasutra of A.D. 1465

The Emergence of A New Pictorial Idiom & The Decline of An Older One ; New Stylistic Features , Anticipating The Emergence of The New Style :[Manuscripts Constituting The Foundation For The Evolution of The C.P. S. Style ; Departure From The Western Indian Style]

The miniatures of this particular manuscript signifies the emergence of a new pictorial idiom and the decline of an older one. Thus the style raises questions pertaining to this morphological process. It is now been fairly accepted and established that this manuscript like the Mandu Kalpasutra of A.D. 1439 and the slightly later Jaunpur Kalpasutra of A.D. 1465, constitute the basis for the emergence of the Caurapanchasika style . A departure from the usual norms of the Western Indian style and an anticipation of the Caurapanchasika style is observable in the stylistic features such as the conception of the human figure, the palette of bright colours and the treatment of nature.

The Chaurapanchasika Style An Original & Stylistic Movement: The Production of Mandu Kalpasutra Group; the Gwalior Ms. of A.D. 1441 A.D. Stylistic Advancement In Digambara Mss.

The Caurapanchasika style was in fact an original and independent stylistic movement. The Mandu Kalpasutra group was actually produced as a result of the impact of the Chaurapanchasika style on the northern variant of the Western Indian style .The evidence of this development is provided by the Gwalior manuscript of A.D. 1441 and other related manuscripts from the Digambara Jain bhandaras , especially the style of the Digambara Jain manuscripts which are indicative of this advancement .The authenticity or certainty for this suggestion is further testified by the intrusion of the Caurapanchasika style –elements in the Western Indian styled manuscripts , which differ from the Mandu Kalpasutra group . This is in fact a sure evidence of the influence which obviously flowed from a comparatively more vigorous source.

Signs of Advancement; Emergence of Provincial / Regional Sultanates: Stimulating Effect On Art & Culture : Northern Variant of The western Indian Style ; Mandu Kalpasutra , 1439 Manuscripts Illustrated In Delhi –Muni Punyavijayaji – Kalakacharyakatha of 1430 :

The disintegration of the Delhi Sultanate and the emergence of the regional or provincial Sultanate kingdoms, had an extremely stimulating effect on the art and culture of the time, though quite ironically it had a disastrous effect on the political situation of the time. It is now clear that the style of the Mandu Kalpasutra of A.D. 1439 , represents the northern variant of the Western Indian style harnessed in the service of iconography developed in Western India . It is important and rather significant to note that since the colophon of the manuscript is in a different handwriting and ink than that used in the text of the manuscript, it is quite possible that the, manuscript was illustrated in Delhi and then brought to Mandu for donation. The Muni-Punyavijayaji-Kalakacharyakatha , appears to have been painted in Delhi in c. A.D. 1430 .

Gwalior Artistic Efflorescence: Tomar Rajas: Independent Hindu Kingdom Under Tomar Rajputs : Muni Punyavijayaji Kalakacharya of 1430 ; Independent Hindu Kingdom Under Tomar Rajputs :

Gwalior established its identity as an independent Hindu kingdom under the rule of the Tomar Rajputs immediately after Timur's sack of Delhi. The Delhi Sultanate could only recover Gwalior in A.D. 1518 , when the kingdom fell to the conquering forces of Sultan Ibrahim Lodi .The artistic and cultural activities of this mediaeval- Hindu kingdom is reflected in the efflorescence and cultural ferment evidenced in the spheres of literature , music and architecture as a result of the untiring and devoted patronage and encouragement of the Hindu Rajas of the kingdom .

Raidu; Dungar Singh Tomar & Kirti Singh: Cultural & Artistic ferment Due To Untiring & Devoted Patronage (Gwalior Captured By Lodis In A.D. 1518); Raidu's Enthusiastic &



Religious Zeal & Liberal Attitude of The Tomar's –Jain Pilgrim Centres & Illustration of New Mss.

A picturesque description of the city life of Gwalior is available from the writings of Raidhu . The enthusiastic and religious zeal of Raidhu and other Jain personages on the one hand and the liberal attitude of Raja Dungar Singh Tomar and his equally illustrious son Kirti Singh on the other hand appears to have generated an atmosphere of religious fervour in Gwalior. For the Jains of the region, Gwalior became a place of pilgrimage –a centre where new Jain texts were being composed, manuscripts were being copied and occasionally illustrated colossal stone icons of Jain Tirthankaras were also being sculpted in the rocky cliffs along the road leading to the fortress atop the narrow precipitious hill.

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