

Chandrayaan-3: A Case Study in India's Technological Triumph, Tenacity and Impact

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Abstract

Purpose: This case study is an attempt to analyse in depth the various dimensions behind the spectacular success of Chandrayaan-3 mission. The background of this mission was utilised for highlighting the learning that was used from the failure of Chandrayaan-2 mission. The implications of the success was discussed in detail. Library research method (George 2008) was used, secondary data was collected. Secondary data available in public domain, which was used for the study. The study highlights the impact on various dimensions like, psychological, sociological, political, economic etc.

Key words: Chandrayaan-3, Implications of mission, Psychology, Sociology, Politics, Economy.

1. Introduction:

In many countries, the space exploration related work needs astronomical budgets. However, India's Chandrayaan-3 mission stands as a special case to exemplify the power of ingenuity, determination, scientific excellence and achieving the extraordinary within the limited resources. Launched successfully, this mission not only marks a significant technological achievement but also symbolizes the indomitable spirit of human curiosity, aspiration, teamwork, motivation and resilience. After the Chandrayaan-1 mission in 2008, which made a significant discovery of water molecules on the Moon, and the Chandrayaan-2 mission in 2019, which could not make a soft landing, the success of Chandrayaan-3 mission symbolizes India's continued commitment and resilience in lunar exploration.

2. Background:

The Indian Space Research Organisation (ISRO) was established way back in 1969, when India was just in the phase of progress & consolidation after a long period of freedom struggle and was just around 20 years into its independence. The typical 'air' in the country amongst the general population was full of a sense of national pride. In this scenario, ISRO has evolved slowly and significantly, marking its journey from launching small satellites to executing complex lunar missions. This evolution right from beginning was a proof of India's growing capabilities in space technology.

On 23rd August 2023, the Chandrayaan-3 made successful soft landing on the moon's South pole, making India the first country to have this historic achievement. India became the fourth country after United States, China, and Russia, to have successfully landed on the moon's surface. The lander module was having the lander (Vikram) and the 26 kg rover, named as Pragyan. Chandrayaan-3 mission was launched on 14th July 2023 onboard Launch Vehicle Mark-III (LVM-3) rocket, for a 41 days journey to reach near the lunar south pole. The Chandrayaan-3 mission was part of ambitious program of the Indian Space Research Organisation (ISRO). We remember the Chandrayaan-1 mission which was launched in 2008, which discovered water molecules on the Moon, and then the Chandrayaan-2 in 2019, which aimed at a soft landing but faced a setback at the last moment. After that, Chandrayaan-3's journey reflects perseverance and resilience of the team. The objective of this mission was to ensure successful soft landing at the surface of South Pole of moon. This area was not explored by any other country. The success of Chandrayaan-3's mission was an important part of India's lunar exploration efforts, and it is an example of India's resolve of technological and economic achievements considering India's evolving socio-economic and political

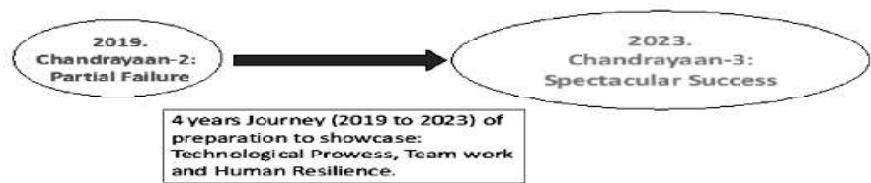


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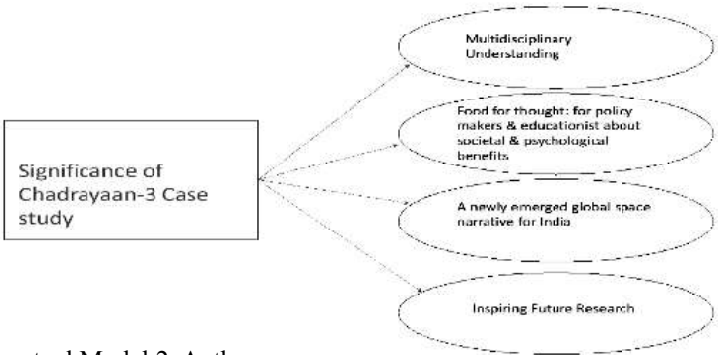
landscape. This study is an attempt to explain that how this challenging mission was achieved with a cost-effective approach and using indigenous technology. It also reflects India's socio-political scenario, economic priorities, and technological advancement. This case study explores the psychological impact of Chandrayaan-3 mission on the Indian masses, especially in terms of national pride, collective motivation, and the triggering of scientific curiosity amongst the youth of India. It examines the sociological implications of the mission, considering how the success of the mission affects India's internal social dynamics, including perception of the general public and influencing the youth for science and technology stream. The case study also analyses the political narratives surrounding Chandrayaan-3, explaining that how the success of this mission has reinforced India's global position and respect as a rising space power capable of ambitious space missions on a limited budget and resource. This includes an assessment of the mission's role in India's diplomatic relations with other countries and its contribution to international space collaborations. In brief, this study provides a multidisciplinary perspective on Chandrayaan-3 mission, incorporating elements from psychology, sociology, political science, economics etc., to offer a holistic view of the mission's impact on India and its standing on global image.

Chandrayaan- 2 mission and it's failure:

India's second moon mission Chandrayaan -2 was launched by Indian Space Research Organization on 22nd July, 2019, but it was heart-breaking for every Indian in September 2019 when they were looking at the landing process and suddenly their TV screens froze, and eventually, ISRO lost all contacts with the Vikram lander which was expected to land on the moon's surface. The contact with the lander was lost just 400 meters away from the landing surface of moon. The available reason of crash- landing of Vikram lander was that it tilted 410 degrees instead of the planned 55 degrees. When the Vikram lander tilted from its set trajectory, the scientists could do nothing but be silent spectators. As per experts in Indian Space Research Organization (ISRO), the velocity of the lander was supposed to slow down from 6000 kmph to 0 kmph in four phases, but the space agency lost contact with it minutes before its touchdown. The scientists were of the opinion that a software glitch was attributed as the reason behind losing contact with the lander. Due to the change in trajectory and the lack of speed reduction, the Vikram lander along with the moon rover Pragyan crash landed on the Moon.



Conceptual Model 1: Author



Conceptual Model 2: Author

A glimpse of various theories which can connected with the success case of India's Chandrayaan-3 mission:

Some of the following theories are connected with the Chandrayaan-3 mission.

Innovation Diffusion Theory (IDT): This theory was proposed by Everett Rogers. Going by this theory, the technological innovations of Chandrayaan-3 can be communicated and adopted within the scientific community of India and beyond. This IDT framework helps in understanding the dissemination of new technologies developed and their adoption by other sectors and the overall impact on India's technological landscape.

Social Cognitive Theory (SCT): This theory was proposed by Bandura. As per this theory, we can examine the psychological impacts of the success of Chandrayaan-3 mission. This theory focusses on observational learning, self-efficacy, and social influence. It helps us to understand how the success of this mission influences the perception of the general public of the country regarding the strength of science, the motivation of young students for STEM fields and the collective belief in technological capabilities.

Postcolonial Theory: This theory was proposed by Edward Said (1978). Postcolonial Theory can be used to explore the effects and legacies of colonial mindset. And this can be applied to assess how the success of Chandrayaan-3 is changing the narrative of India's scientific and technological progress on the global stage. This theory helps one to facilitate the analysis regarding how the success of Chandrayaan-3 mission has challenged the traditional power dynamics of the countries in area of space exploration and how it is contributing to help India getting a new identity as a space power.

Public Goods Theory: This theory was proposed by Paul Samuelson (1954). This theory can be very well utilised to assess the economic implications of the Chandrayaan-3's mission. It will help in analysing how the mission, as a public good, has contributed to the national economy, its impact on public spending, and how it provides direction for economic activities in related other sectors as well.

Geopolitical Theory: One of the geo political theories was proposed by Mackinder (1919). The case study leverages the various geopolitical theories to understand the political implications of the success of Chandrayaan-3. The scope of examining the geo-political impact may include how the Chandrayaan-3 mission has influenced India's international relations, the diplomatic strategies in the context of space exploration, and how it shapes India's geopolitical standing in the world.

Cultural Theory of Risk: This theory was propounded by Mary Douglas et al. (1980). The theory tries to explore that how different societies and nations perceive risks and respond to such risks. This theory can be applied to understand public and institutional responses to the risks associated with the mission of Chandrayaan-3. This includes the perception & impact of the mission's success or failure. It may influence the decision-making of the society and the nation in future space endeavours.

The above-mentioned theories set the foundation for an in-depth analysis of the Chandrayaan-3 mission from multiple perspectives. By applying these theories, we can get a comprehensive understanding of the technological, psychological, economic, political, and cultural dimensions of the mission and its broader implications for India and the global community.

3. Insight into various aspects which are connected with India's Chandrayaan-3 mission:

Technological and Economic aspect:

Many studies (e.g., Nair, 2021; Kapoor & Singh, 2022) have conducted studies on the technological innovations and cost-effective strategies in India's space missions, particularly Chandrayaan-3. These studies highlight how the approach of ISRO disrupts the high-cost model which traditionally adopted by other countries on space exploration.

Research by Patel and Kumar (2023) suggests high economic implications of such missions for some other countries which are emerging economies. The study says that success of such missions has the ability to offer blueprint for cost-effective space exploration and at the same time stimulating the technological advancements and industrial growth.

Psychological Impact:

Research work of Desai and Sharma (2022) suggest huge impact due to psychological

Table 1.
sample characteristics

upliftment and national pride experienced by the Indian population due to the success of such missions of national importance. Findings also suggest a significant boost in national self-esteem and boosting the interest of the youth in STEM fields.

Ghosh (2023) talks about the phenomenon of 'collective resilience' after the setback of Chandrayaan-2 mission, and emphasizing how Chandrayaan-3 became a symbol of perseverance and optimism for the Indian population and youth.

Sociological Perspectives:

Studies by Rao and Nandan (2024) suggest high sociological impact of space missions in India, particularly it's influence on education, scientific literacy, and public engagement in science.

Studies by Singh and Ali (2023) discussed how such missions can be useful to bridge social divide in India and foster a sense of unity and shared purpose. It further examines the role of media in shaping public perception.

Political Science and International Relations aspect:

Research by Krishnan and Lee (2023) talks about geopolitical implications of Chandrayaan-3, analysing how India's space achievements enhance its international stature and diplomatic leverage to a great extent.

Research by Banerjee (2022) provides a comprehensive view of how space missions like Chandrayaan-3 contribute to soft power dynamics, improving India's global image and providing opportunities for international collaborations.

Global and Regional Implications aspect:

The work of Thakur and Nguyen (2024) helps to have discussions on the global context. The work examines the role of the newly emerging space powers in democratizing space exploration and challenging the traditional space power hierarchy. Comparative studies by Mehta and Park (2023) also highlight how India's space programs, exemplified by missions like Chandrayaan-3, influence and inspire other countries in Asia and beyond to invest in space research and exploration.

As mentioned above, the existing secondary data provides a comprehensive understanding of the Chandrayaan-3 mission's multidimensional impacts. Technologically and economically, it is heart-warming to see the paradigm shift regarding the way space missions are approached by emerging economies. Psychologically, it has given a huge boost to national pride and collective resilience. Sociologically, it has enhanced scientific engagement and unity amongst the youth and the population in general. If we analyse politically, we find that it has significant implications for India's global standing and diplomatic relations. And on a global scale, the success of this mission contributes to the narrative of space exploration becoming more inclusive and diverse. This case study shows the multifaceted nature of Chandrayaan-3's impact but also sets the stage for further research in these domains.

4. Gaps that were found in different studies:

Gap in currently available studies: Economic Impact:

While Patel and Kumar (2023) talks about the economic benefits of cost-efficient space missions, however there is a notable gap in empirical data quantifying the direct and indirect economic impacts of Chandrayaan-3 on India's economy. That means, so far, we do not have specific findings which can provide measurements regarding economic outcomes, like job creation, industrial growth, or educational investments etc.

Gap in currently available studies: Longitudinal Psychological Studies:

The research by Desai and Sharma (2022) provides initial insights regarding the psychological effects of Chandrayaan-3. However, there is a lack of longitudinal studies that track these effects over time. There is a need to have such tracking by way of studies which may show up data regarding change in perception and attitude in long term, after the success of such Chandrayaan-3 mission.

Gap in currently available studies: Regional Sociological Differences:

Rao and Nandan's (2024) study explains the sociological impacts of Chandrayaan-3 in India.

However, as India has diversity in terms of regions and demography. Hence, there is lack of research findings considering such factors, which is required, considering India's diverse socio-cultural fabric.

Gap in currently available studies: Detailed Policy Analysis:

Krishnan and Lee's (2023) work on the geopolitical implications of Chandrayaan-3 talks about general trends in India's international relations. However, there is need to have in-depth studies to get insights on policy changes, diplomatic initiatives etc, which are influenced by the success of this mission.

Gap in currently available studies: Comparative International Analysis:

Work of Thakur and Nguyen (2024) compared the role of emerging space powers in the global arena. However, there is a scarcity of studies which can compare the approach, challenges, and successes of similar missions of other countries with India's Chandrayaan-3. Such comparative analyses may be helpful for in-depth understanding of different strategies in space exploration.

Gap in currently available studies: In-depth Technological Assessments:

The current available work talks good about the technological advancements of Chandrayaan-3 (Nair, 2021; Kapoor & Singh, 2022). However, there is shortage of detailed critical assessments of the technology used, especially in comparison to international standards, including evaluating the reliability, scalability, and potential areas for technological improvements.

Based on above, we find that there are notable gaps and areas where more in-depth research work is needed. The required research work is expected to address economic impact assessments, long-term psychological studies, sociological analysis across different Indian regions, detailed policy and technological assessments, comparative international studies etc. Research work addressing such gaps would be useful to provide holistic and detailed understanding of the mission's multifaceted impacts.

The main objective of the Chandrayaan-3 mission was to have a soft landing on the lunar surface. The mission was having a rover to study the lunar terrain and to gather scientific data, especially near the South Pole of the moon, an area which was not explored by previous missions. Lunar lander and rover were the key components. Lunar lander was equipped with instruments for navigation, communication, and scientific experimentation. Rover's job was to move on the lunar surface, it was having scientific instruments to analyse the lunar soil. This mission used India's own technology, exhibiting India's growing prowess in space technology. Chandrayaan-3 mission took learning from the failure of Chandrayaan-2 mission and it incorporated advanced navigation, propulsion, and communication systems. Chandrayaan-3 mission was known for its cost-effectiveness. The mission exemplifies efficient budget management in space exploration, a significant achievement for our country balancing economic developmental challenges plus the challenges of other priorities and scientific ambition. The success of this mission has an impact on India's international standing as a powerful space exploring nation. The success of this mission has contributed for India's national pride and demonstrates India's capability in high-tech sectors on the global stage. Politically, it is a major event which has enhanced India's diplomatic relations and collaboration in space technology. The mission has positively influenced the Indian collective psyche, inspiring a generation towards science and technology. The mission is an example of resilience, especially after the partial failure of Chandrayaan-2, without losing momentum and motivation; it promoted a culture of innovation and persistence. Chandrayaan-3 plays an important role in global space exploration. It adds to our better understanding of the Moon, particularly the unexplored South Pole region. The mission facilitates more collaboration of different countries in space exploration and sets an example for other countries with emerging space programs. Success of Chandrayaan-3 mission stands as a hallmark of technological achievement, economic efficiency, and socio-politically better scenario for India. It exemplifies how space exploration can be a catalyst for national development, international collaboration, and human aspiration. This case of Chandrayaan-

3 mission helps us in understanding multifaceted impacts and contributions to space exploration and beyond.

The 21st century witnessed renewed interest in lunar exploration. This phase found several countries and private organizations participating in the space race. Chandrayaan-3 mission of India, is part of this global trend, aiming to contribute significant scientific knowledge about the Moon. This mission unfolds against the backdrop of India's unique socio-economic challenges and aspirations, where there has been need to make investments in many areas of priorities. India had to take a balanced approach between economic development and technological advancement and the space mission. The Chandrayaan-3 mission of ISRO represents a strategic investment in science and technology. The Chandrayaan-3 mission is not merely a scientific venture but is a result of historical progress, Indian population's aspirations and the contextual necessities. Today, space exploration of India stands at the intersection of India's ambitious space goals and its broader national aspirations, reflecting a complex interplay of technological innovation, societal influence, and geopolitical strategy. This background forms the essential foundation for understanding the multifaceted nature of the mission and its wide-ranging impacts.

India's Chandrayaan-3 mission was highlighted in terms of technological innovations, especially in terms of its lander and rover design (Nair, 2021; Kapoor & Singh, 2022). These advancements were the result of the direct response to the challenges faced in Chandrayaan-2 mission. This suggests a paradigm shift of 'learning through failure' in ISRO's approach and a 'never say die' mindset, exemplifying resilience and adaptability. The mission's success not only enhances India's lunar exploration strength and potential but also contributes to global space technology. Studies by (Patel & Kumar, 2023) emphasize the cost-effective nature of the Chandrayaan-3 mission. Despite budget constraints, the ISRO could successfully execute a complex lunar mission. This drives the idea that important and complex space exploration is achievable even without huge spending. This also throws light on broader economic strategy, positioning India as a leader in cost-effective space technology. Studies conducted by Desai and Sharma (2022) indicate huge boost in national pride and new interest generated in youth for STEM fields, post-Chandrayaan-3 success. This aligns with Ghosh's (2023) findings on the mission enhancing collective resilience and optimism. Chandrayaan-3 has significantly influenced India's collective psyche, driving a science-positive culture and strengthening national identity. The success of Chandrayaan-3 mission has become a symbol of hope and determination, inspiring societal change and huge positive impact. Studies by Krishnan and Lee (2023) shows that the mission's success has elevated India's status in the international arena, enhancing its geopolitical influence. The mission has enhanced India's diplomatic standing, showcasing its technological prowess. This indicates a shift in global space dynamics, where India has gained prominence. The studies by Thakur and Nguyen (2024) throws insights regarding success of Chandrayaan-3 mission playing role in bringing out a feeling of a democratic and balanced, orderly standing of the countries in area of space exploration, a clear challenge to the traditional space power hierarchy. The mission is an example for other countries which are just in growing and nurturing stage of space programs, showing that strategic investment in space technology can yield substantial global and regional influence.

Success of Chandrayaan-3: Prowess of Technological Ingenuity:

Chandrayaan-3 is known for its low budget project, achieved through efficient engineering and leveraging experiences from previous missions. The mission showcases a range of indigenously developed technologies, including a lunar lander and rover, highlighting India's growing capabilities in space technology. The design incorporates lessons drawn from Chandrayaan-2 mission, having improvements in navigation, propulsion, and communication systems to enhance landing precision and reliability.

Success of Chandrayaan-3 mission: Human Spirit and Motivation exemplified:

The mission's development, following the partial failure of Chandrayaan-2, is a narrative of resilience, reflecting a 'never give up' attitude. Chandrayaan-3 serves as an inspiration, particularly to the youth in India and around the world, demonstrating that ambitious goals

are achievable with persistence and hard work. The mission has helped to enhance international collaborations and partnerships, promoting a spirit of global cooperation in space exploration.

Some key people behind success of Chandrayaan-3 mission:

ISRO Chairman S Somnath played a crucial role in the mission's success, implementing a strategy focused on eliminating failures. Project Director P Veeramuthuvel, Deputy Project Director Kalpana K, and Directors Nilesh M. Desai, S Unnikrishnan Nair, and M Sankaran also contributed to the mission's success.

The statements of some of the team leaders after the success of Chandrayaan-3 mission: One team leader of ISRO said "Team ISRO has been breathing, eating, drinking, Chandrayaan-3 for the last 3-4 years". Just after Chandrayaan-3 was safely placed in orbit, ISRO Chairman Dr. Somanath said: "Congratulations India. Chandrayaan-3, in its precise orbit, has begun its journey to the Moon. Health of the spacecraft is normal." Ex ISRO chief K Sivan hailed soft landing of Chandrayaan-3. Prime Minister Sh. Narendra Modi said on Chandrayaan-3's successful landing "This success belongs to all of humanity and it will help moon missions by other countries in the future,"

S. Somanath, Chairman of the Indian Space Research Organisation (ISRO), attributed the success of the Chandrayaan-3 mission to "the result of the hard work of thousands of people in ISRO", the "rigour of the reviews", and "corrective actions taken meticulously." Right from the launch till landing, the process happened flawlessly, as per the timeline. Project Director Veeramuthuvel said "Chandrayaan-3 success owed to the combined effort of entire team". All the teams like, navigation guidance and control team, propulsion team, sensors team and all the mainframe subsystems teams, critical operations review committee etc., worked meticulously, ensuring success to the mission. The culture, the team work, the human effort in ISRO organization is at tremendous level.

Chandrayaan-3 was a follow-on mission to Chandrayaan-2. The partial failure of Chandrayaan-2 happened due to anomalies in the braking system in the module while attempting to land on 7th September 2019, when its lander 'Vikram' crashed on the surface of the Moon. The spacecraft was rebuilt after the Chandrayaan-2 experience.

Team ISRO feels that Chandrayaan-3's success has put more responsibility on them because this success has set the bar so high, and hence similar or more challenging missions will be inspiring the whole ISRO team in the future.

5. Limitations of this case study:

Library research method (George 2008) was used. It relies on secondary data, which might limit the ability to explore certain aspects that haven't been extensively covered in existing literature.

6. Conclusion:

Chandrayaan-3 mission was more than a lunar exploration mission; it was seen as a beacon of hope and a demonstration of what can be achieved when technological innovation is coupled with human determination, in spite of budgetary constraints. This mission did not just aim to expand the human's understanding of the moon but also stands as a symbol of human aspiration, inspiring generations to look beyond the horizon and reach for the stars. This work provides insights about multi-dimensional impact of this mission. Technologically, it marks a significant advancement in lunar exploration showing India's prowess in the field. It sets a precedent for economically cost-effective space missions. The mission has a profound impact on India's societal fabric, enhancing scientific temperament and national pride, a space for further study under psychological impact. Mission's success further repositions India on the global stage, getting a great political mileage, contributing to a more inclusive and diverse space exploration narrative. These findings underscore the Chandrayaan-3 mission's role not just in scientific achievement but in shaping a nation's identity and aspirations.

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