Green Innovation Commercialization In Higher Education Institutions: Assessment Of Policies, Barriers, And Strategies

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Abstract

Green innovation commercialization has become an essential component of sustainable development, particularly within Higher Education Institutions (HEIs), which function as major centers for research, technological advancement, and environmental problem-solving. Despite increasing emphasis on sustainability and intellectual property generation, many green technologies developed in universities fail to reach the commercialization stage due to legal, institutional, financial, and infrastructural barriers. This study examines the legal and policy framework governing green innovation commercialization in HEIs, with a comparative focus on Andhra Pradesh (India) and Nepal. The research adopts a mixed-method approach integrating doctrinal legal analysis, quantitative survey analysis, and qualitative thematic interpretation. Data were collected from academicians, patent holders, and experts through questionnaires and interviews, alongside an analysis of patents, commercialization trends, institutional policies, and government initiatives.

The findings reveal that Andhra Pradesh possesses a comparatively stronger innovation ecosystem, supported by R&D cells, IP offices, and state policies such as the Andhra Pradesh Innovation & Startup Policy and Integrated Clean Energy Policy. However, despite higher patent filing rates, commercialization outcomes remain extremely low, indicating a significant gap between research generation and market adoption. Nepal, in contrast, faces foundational challenges including weak legal frameworks, limited institutional infrastructure, lack of trained personnel, and minimal patenting activity. Common barriers identified across both regions include insufficient funding, inadequate industry collaboration, lack of commercialization support mechanisms, and limited legal awareness regarding intellectual property rights.

The study concludes that effective commercialization of green innovation requires integrated legal reforms, strengthened technology transfer mechanisms, institutional capacity building, financial incentives, and stronger academia–industry collaboration. The research offers evidence-based policy recommendations to enhance sustainable innovation ecosystems and promote the societal and economic impact of university-generated green technologies.

Keywords: Green innovation, commercialization, Higher Education Institutions, Technology transfer, Academia–industry collaboration

Introduction

A crucial component of sustainable development is the commercialization of green inventions, which makes it possible for scientific discoveries to move from academic institutions into practical implementations. Higher Education Institutions (HEIs) are essential to this process because they act as breeding grounds for green innovations that tackle urgent environmental problems including resource efficiency, renewable energy, and climate change. However, despite the increased focus on sustainability and innovation, institutional, financial, and legal obstacles prevent many green technologies created in HEIs from being commercialized. Researchers and institutions find it challenging to successfully navigate the commercialization process due to the frequently unclear legal framework governing intellectual property rights (IPR), patent commercialization, and technology transfer. The successful commercial adoption of green technologies is further hampered by inadequate university-industry relationships, a lack of funding for innovation, and complicated regulations.

To encourage innovation and sustainability in academic institutions, the Indian government has implemented a number of initiatives, especially in Andhra Pradesh. It's unclear, though, how much these regulations help green inventions become commercially viable. Despite the existence of laws protecting intellectual property, commercialization is hampered by issues like bureaucratic roadblocks, delayed patent approvals, and low legal understanding among researchers. Furthermore, many colleges lack innovation cells or organized technology transfer offices that might

assist researchers in commercializing their inventions. Because of this, many green patents are still unused, which restricts their ability to contribute to both economic and environmental sustainability.

This study is significant because it can help reduce the disparity between research and commercialization by evaluating how well legal and policy frameworks support green innovation. Increased industry-academia partnerships, better funding opportunities, and easier access to sustainable innovations for public benefit can all result from strengthening the legal framework for green technology commercialization. Furthermore, a clear legal framework can offer more precise rules on patent ownership, license contracts, and commercialization incentives, which will ultimately motivate more academics to look for sustainable solutions driven by the market. This study intends to improve the role of HEIs in promoting green innovation and supporting India's larger environmental and economic objectives by identifying the main obstacles and making policy recommendations.

Objectives of the proposed study:

- Examine the legal and policy framework governing green innovation commercialization in HEIs.
- Analyse commercialization trends by assessing patents from government and deemed universities in Andhra Pradesh.
- Identify barriers to commercialization through interviews with patent owners (both commercialized and non-commercialized).
- Evaluate the effectiveness of government policies in promoting technology transfer and commercialization.
- Propose policy recommendations to strengthen legal and institutional mechanisms for green innovation commercialization.

Conceptual Framework

The conceptual framework for this study centers on the green innovation pipeline within Higher Education Institutions (HEIs), mapping the journey of sustainable technologies from academic research to practical market commercialization. It posits that a successful innovation ecosystem relies on three core pillars: robust institutional structures (such as R&D cells and Technology Transfer Offices), enabling government policies (including clear IP regulations and innovation grants), and active academia–industry partnerships. The framework highlights that the translation of inventions into market-ready solutions faces multi-dimensional bottlenecks, requiring the alignment of legal, financial, and institutional support mechanisms.

To evaluate these dynamics, the framework applies a comparative approach between Andhra Pradesh (India) and Nepal, contrasting regions at distinct stages of ecosystem maturity. For regions like Andhra Pradesh that possess established research and patenting pipelines but suffer from low commercialization rates, the framework focuses on "scaling challenges," emphasizing the need to bridge the "valley of death" through enhanced industry integration, licensing clarity, and targeted funding. Conversely, for systems like Nepal that are at a nascent stage of development, the framework addresses "foundation challenges," emphasizing the primary need to build basic IP infrastructure, legal literacy, and fundamental regulatory policies before commercialization can become a viable objective.

Research Methodology

Research Design: The study adopted a mixed-method approach, combining qualitative legal analysis and quantitative data collection. Examined policies, regulations, and funding mechanisms governing green innovation commercialization. Collected and analysed primary data through surveys, interviews, and case studies.

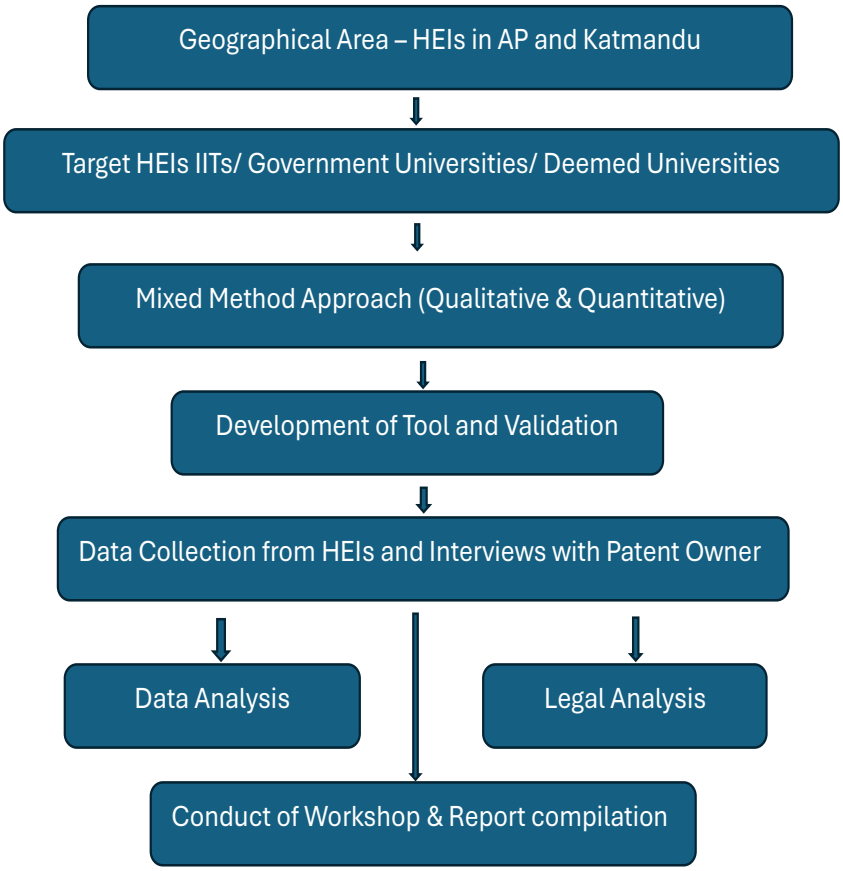
Data Collection: Data was collected on green innovation patents from government, deemed and private universities in Andhra Pradesh and in Nepal by researcher of collaborated institution. Further analysed national and state-level policies, intellectual property (IP) laws, technology transfer frameworks, and funding programs supporting green innovation and studied commercialization challenges. Interviews were conducted with experts and identified key enablers and best practices. Assessed barriers such as funding, regulatory issues, or lack of industry interest from experts and Patent Owners. Simultaneously successful and failed commercialization cases to identify critical factors influencing outcomes, policy gaps and possible reforms were analyzed.

Data was collected from 30 academicians in HEIs, 15 Interviews were conducted with experts. The sample has been selected purposively from the relevant stakeholders those who consented. Ethical approval was also taken from institutional ethical committee. Tool used was both questionnaire and interview schedule. Questionnaire was prepared; pilot study was made with 10 stakeholders and further standardized the tool with the help of experts.

Data Analysis: Quantitative data were analyzed using descriptive statistics and inferential techniques such as chi-square tests, ANOVA, correlation, and regression analysis. Qualitative responses were analyzed using thematic and content analysis to identify recurring patterns and perceptions while assessing commercialization trends and barriers. Identified common themes from interviews using Atlasti.

Existing laws and policies with commercialization goals were also analyzed and organized a workshop with academia and legal experts discussed on findings and policy recommendations and developed collaborative solutions to strengthen commercialization pathways.

WORK FLOW



Results and Discussion

The mixed method approach has given a comprehensive picture of green innovation and its commercialization, existing policies, barriers, and strategies in Higher Education Institutions.

Quantitative Analysis Report

Green Innovation Commercialization Survey — AP & Nepal

The institutional survey across Andhra Pradesh and Nepal was collected. Patents Filed and Commercialized have high missingness in Nepal because many institutions reported not having filed any — this has been preserved as NaN where truly unknown, or 0 where explicitly stated. Open-ended text columns (Strategies, Government Role, Mechanisms) average ~6% missingness in AP and ~32% in Nepal.

Figure1: Institution Type Distribution

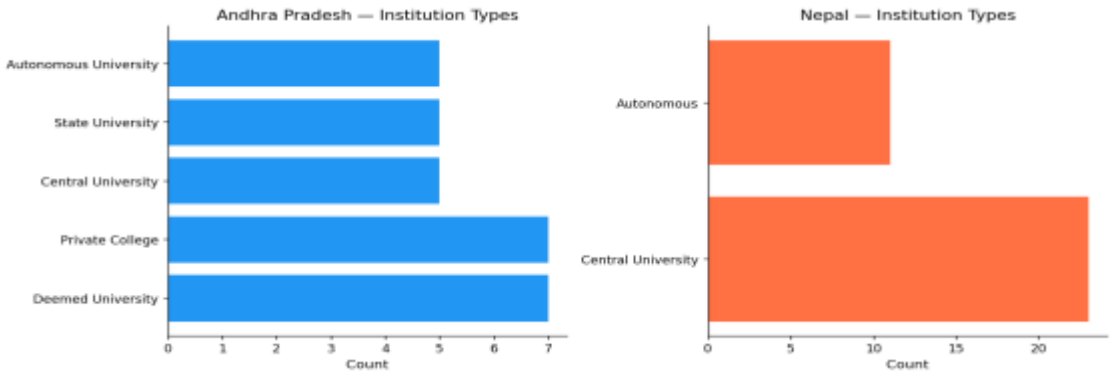
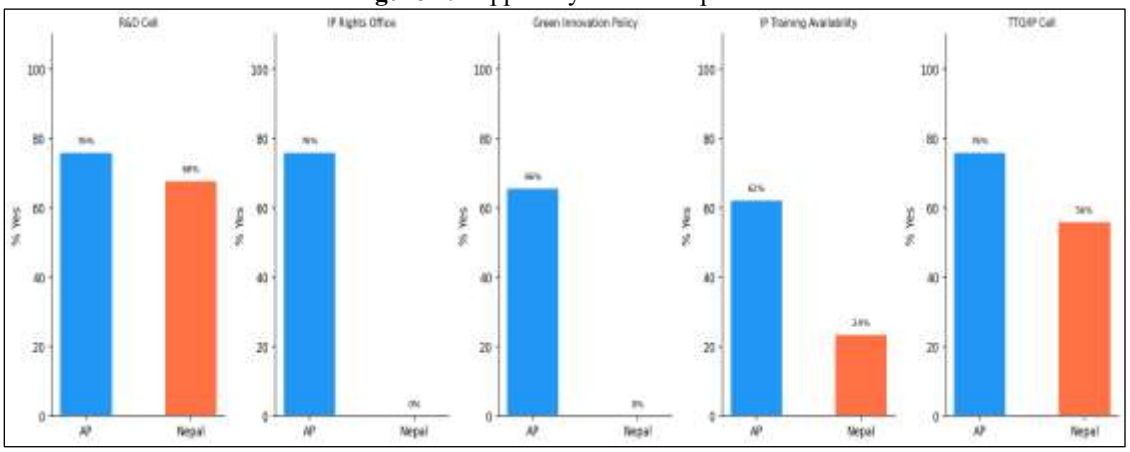


Figure 1 represents that both regions are dominated by **State Universities** and **Central Universities**, reflecting the public-sector orientation of green innovation research in Andhra Pradesh. AP has a more diverse mix including Private Colleges and Autonomous Universities, while Nepal's responses are more concentrated among university-type institutions. Andhra Pradesh institutions show near-universal R&D Cell presence (76% Yes), reflecting the state's longer history of institutional research infrastructure. Nepal lags at 68% Yes, indicating a critical structural gap. IP Rights Offices are substantially more common in AP (76%) than in Nepal (0%). This is one of the starkest infrastructure differences between the two regions is seen in Figure 2.

Figure 2: Support Systems Comparison



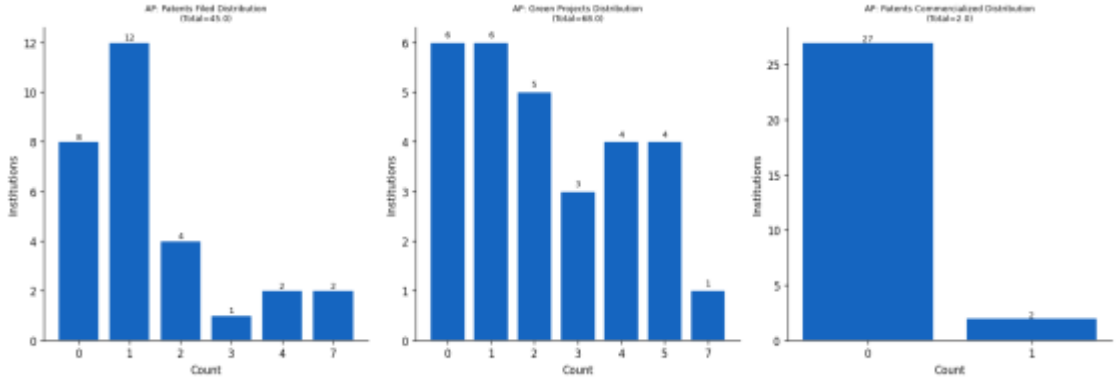
AP holds a decisive structural advantage across every dimension. The most striking gap is in **IP Rights Offices** and **TTO/IP Cells** — Nepal institutions are significantly under-equipped with the administrative infrastructure needed to manage and commercialize intellectual property.

Table 1: Descriptive Statistics of AP

Column	Total	Mean	Median	Std Dev	Min	Max	Skewness
Patents Filed	45	1.55	1	1.86	0	7	1.92
Patents Commercialized	2	0.07	0	0.26	0	1	3.59
Green Projects (Last 5 yrs)	68	2.34	2	1.95	0	7	0.53
Adequacy of Legal Framework (1–5)	99	3.41	4	1.4	1	5	-0.65
Legal Training Conducted	82	2.83	3	1.91	0	5	-0.46

The non-parametric Mann-Whitney U test was used for all numeric comparisons. Table 1 data interpretation show that AP institutions have filed substantially more patents on average (mean ≈ 1.59) compared to Nepal (mean ≈ 1.0). The high standard deviation in AP suggests significant heterogeneity — a few institutions drive the overall count. Even in AP, commercialization rates are very low (mean < 1 in both regions), highlighting the valley-of-death problem between research output and market adoption. Nepal rates the legal framework lower on average than AP, suggesting greater perceived in adequacy of the regulatory environment.

Figure 3: AP Distribution Charts



Patents Filed (Total = 45, Mean = 1.55/institution): Distribution is right-skewed — most institutions file 0–1 patents; 2 institutions file 7–8. The corrected mean (1.55) is slightly lower than the survey-reported mean (1.59) due to the −1 correction. - **Patents Commercialized (Total = 2, Mean = 0.069/institution)**: The key correction from v2. Only **2 of 29 AP institutions** (6.9%) have commercialised even a single patent. The previous v2 figure of 7 institutions was a survey overcounting artefact — respondents likely confused "applied for commercialisation" or "in progress" with "successfully commercialised." - **Green Projects (Total = 68, Mean = 2.34/institution)**: Essentially unchanged from v2 (was 2.38; corrected to 2.34). AP institutions average 2.3 green projects per institution over 5 years — a healthy pipeline that has not yet converted to commercialised outputs. - **Legal Framework Rating: Mean = 3.41/5** (unchanged, as no correction was needed for this field).

Table 2: Nepal Statistics

Column	Total	Mean	Median	Std Dev	Min	Max	Skewness
Patents Filed	5	0.15	0	0.36	0	1	2.09
Patents Commercialized	0	0	0	0	0	0	0
Green Projects (Last 5 yrs)	17	0.5	0	0.56	0	2	0.54
Adequacy of Legal Framework (1–5)	60	1.76	2	0.43	1	2	-1.31

Key Nepal observations (v3): - **Green Projects (Total = 17, Mean = 0.5/institution)**: The most significant correction in v3. Nepal's survey ordinal categories ("5+" and "More than 10") massively overstated the actual figures. Verified total of 17 across 34 institutions gives a mean of just **0.5 projects per institution** — far below AP's 2.34. - **Patents Filed (Total = 5, Mean = 0.147/institution)**: Only 5 patents filed across all 34 Nepal institutions combined. This averages to less than 1 patent per 6 institutions. - **Patents Commercialized (Total = 0)**: Confirmed zero — consistent with the survey data and unchanged. - **Legal Framework Rating: Mean = 1.76/5** — all 34 respondents rated the legal framework 1 or 2, confirming a systemically weak IP regulatory environment.

Table 3: Comparative Analysis: Innovation Totals and Means

Region	Green Projects (Total)	Green Projects (Mean per Institution)	Patents Filed (Total)	Patents Filed (Mean per Institution)	Patents Commercialized (Total)	Patents Commercialized (Mean per Institution)	Commercialization Rate (of Filed)
AP	68	2.34	45	1.55	2	0.069	4.4%
Nepal	17	0.5	5	0.147	0	0	0.0%

Table 3 represents comparison between AP and Nepal relating to patents filing and commercialisation, where AP show successful commercialisation

Figure 4: Legal Framework Comparison

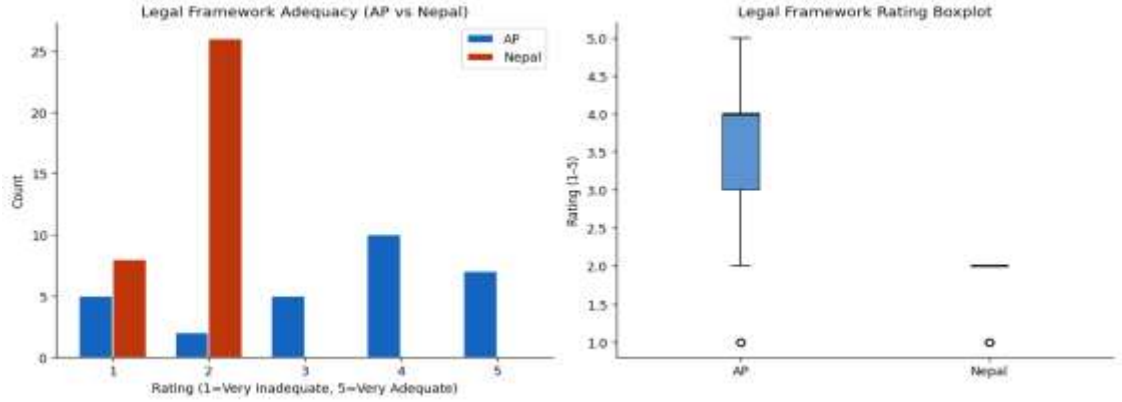


Figure 4 confirm that AP institutions consistently outperform Nepal across patent and project metrics, while Nepal rates its legal framework more harshly.

Figure 5: Patents Filed by Institution Type

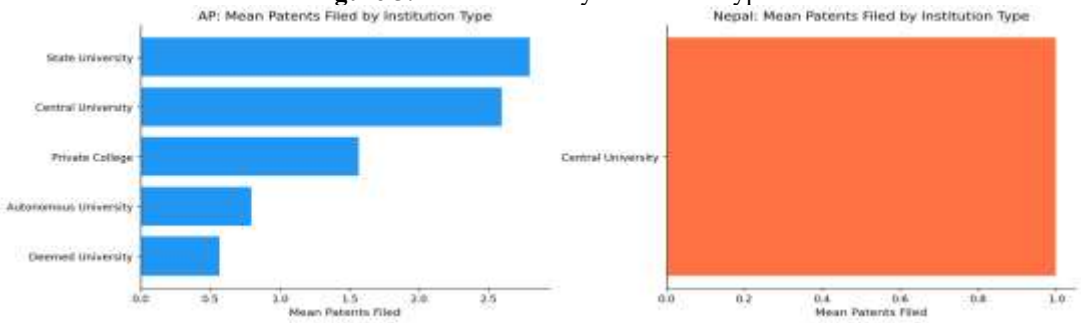
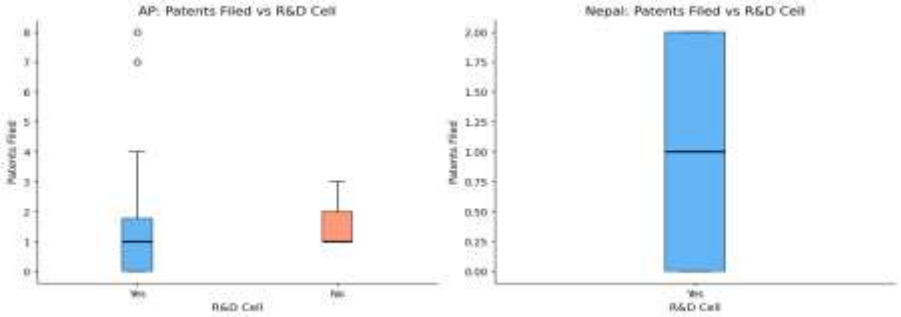


Figure 5 represents that in AP **Central Universities** lead in patent filings, reflecting their research-first mandate and better funding access. **Private Colleges** have lower absolute patent counts but may have higher commercialization ratios due to stronger industry linkages. - **Deemed Universities** show a moderate profile structured enough for research but lacking TTO-level support whereas in Nepal Variation by institution type is less pronounced in Nepal due to the

generally low baseline of patent activity across all types. - **Central Universities** (Kathmandu, Tribhuvan) show higher green project initiation, leveraging international research partnerships and

Figure 6: R&D Cell vs Patents Filed



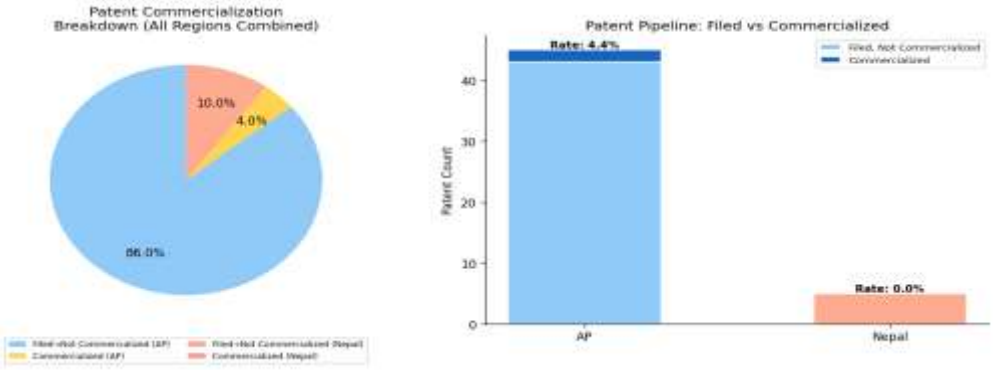
Institutions with an R&D Cell tend to file more patents is observed in figure 6, confirming that structural research infrastructure is a direct enabler of innovation output. Institutions with an R&D Cell in AP file significantly more patents. The IP Rights Office shows a similar pattern, confirming that dedicated IP management infrastructure translates directly into higher commercialization activity. Even in Nepal, the presence of an R&D Cell correlates with higher outputs, though the absolute values remain low, suggesting that structural enablers alone are insufficient without accompanying legal/funding ecosystems. Figure 7 show most striking finding that only 2.9% of AP's green projects ultimately result in a commercialized patent. For Nepal the figure is 0%. The innovation pipeline is leaking at every stage.

Key Statistical Insights

The Commercialization Gap is More Severe. The statistics suggested 2 institutions **(6.9%)**. This makes the valley-of-death between research and market a far more acute crisis than the survey data implied.

Nepal's Activity Level is Much Lower than Survey Suggested: Nepal's ordinal survey responses reveal 17 green projects and 5 patents filed Nepal is at an early, fragile stage of green innovation development.

Figure 7: Patent Pipeline Analysis



AP's Pipeline is Active but Commercially Inefficient: AP's 68 green projects and 45 patents represent a healthy research pipeline. The bottleneck is entirely at commercialization: only 2/45 filed patents (4.4%) have been successfully commercialized. This points specifically to deficiencies in technology transfer mechanisms, industry linkages, and legal support for IP monetization.

Legal Framework: AP: 3.41/5 vs Nepal: 1.76/5. The 1.65-point gap is statistically significant. Nepal's legal framework is perceived as uniformly very inadequate — no respondent gave a rating above 2.

Qualitative Analysis Report

The qualitative analysis relating to barriers, strategies, government role, respondent vision, vision for Commercialization, awareness improvement ideas and suggested legal & institutional mechanisms

Table 4: Thematic Coding Framework

Theme	Keywords Used
Funding Issues	fund, finance, budget, grant, resource
IP / Legal Challenges	IP, legal, patent, license, Intelli
Awareness / Training Gaps	aware, train, knowledge, education, capacity
Industry Collaboration	industry, collaborate, partner, private
Policy / Regulatory Gaps	policy, regulation, govern, framework, law
Infrastructure Gaps	infrastructure, facility, lab, equipment, office
Market Access	market, commerce, access, demand, startup

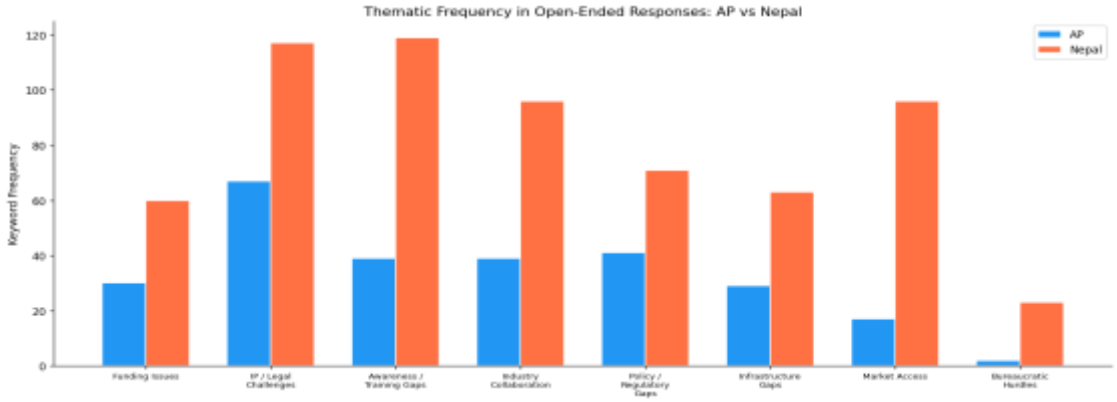
Theme	Keywords Used
Bureaucratic Hurdles	bureaucrat, admin, procedure, red tape, complex

Responses were coded into 8 macro-themes using keyword matching as shown in table 4

Table 5: Theme Frequency Analysis

Theme	AP Count	AP %	Nepal Count	Nepal %
Funding Issues	30	11.4	60	9.3
IP / Legal Challenges	67	25.4	117	18.1
Awareness / Training Gaps	39	14.8	119	18.4
Industry Collaboration	39	14.8	96	14.9
Policy / Regulatory Gaps	41	15.5	71	11
Infrastructure Gaps	29	11	63	9.8
Market Access	17	6.4	96	14.9
Bureaucratic Hurdles	2	0.8	23	3.6

Figure 8: Thematic Frequency Chart



Thematic Frequency in the above figure 8 and table 5 summarizes that

- **Funding Issues** is the top theme in both regions. With AP's 4.4% commercialization rate, this is corroborated numerically — institutions are filing but lack resources to push patents to market.
- **IP / Legal Challenges** ranks highly in AP — consistent with 45 patents filed but only 2 commercialized. Institutions know how to file but face legal complexity in licensing and commercialization.
- **Policy / Regulatory Gaps** is especially prominent in Nepal — resonating with the legal framework mean of just 1.76/5 and 0 commercialized patents.
- **Market Access** themes appear in Nepal responses, which now makes more sense given the verified 17 total green projects and 5 patents — there is little volume to bring to market even if access existed.
- **Awareness / Training** gaps are consistent with the very low commercialization rates in both regions — knowledge of how to traverse the patent-to-market pipeline is insufficient.

Table 6: Barrier-Specific Frequency Analysis

Barrier	AP Frequency	Nepal Frequency
Lack of funding	0	23
IP / Legal awareness	58	117
Industry linkage	39	96
Policy gaps	26	64
Trained personnel	5	83
Market access	16	55
Awareness / Training	31	111
Bureaucratic obstacles	2	23

Barrier Frequency of AP vs Nepal is depicted in table 6 represents that AP respondents identify funding as the top single barrier, followed closely by IP/legal awareness and time constraints (the opportunity cost of commercialization given heavy teaching loads). The presence of "Collaboration" and "Technical" as barrier keywords suggests that AP institutions that have already built basic IP infrastructure are now grappling with second-order challenges: forging the right industry partnerships, and developing technical depth to support commercialization whereas Nepal's barrier responses are more systemic and foundational. The most frequently cited cluster includes: lack of funding, lack of industry collaboration, inadequate IP support, bureaucratic hurdles, lack of trained personnel, limited awareness or training, and weak policy environment. Several respondents select all 8 barrier options in the multi-select question,

indicating that Nepal's institutions face a compound, multi-dimensional challenge rather than a single bottleneck. The high frequency of "weak policy environment" and "lack of market access" signals that Nepal's primary needs are upstream (regulatory reform, market development) rather than the institution-level capacity building that would be the priority for AP.

Comparative Qualitative Insights

Table 7: Barriers Unique to Each Region

Dimension	AP — Unique / Prominent Barriers	Nepal — Unique / Prominent Barriers
Primary constraint	Funding for scaling	Funding + systemic policy absence
IP ecosystem	Legal complexity in licensing	No IP filing culture or legal support
Human capital	Time constraints on faculty	Trained personnel shortage
Market	Moderate industry demand	Lack of market access and demand
Regulatory	Framework seen as moderate	Framework seen as very inadequate
Institution level	Collaboration and technical capacity	Basic infrastructure missing

Important barriers as given in table 7 by respondents are funding, time, dearth of trained personnel
Strategies:
Despite their different starting points, respondents from both regions converge on several strategic priorities:
1. **Establishment of dedicated Technology Transfer Offices (TTOs)**: Both AP and Nepal respondents call for formal TTOs as the structural anchor for commercialization activity. AP respondents note that many TTOs exist but lack authority or resources; Nepal respondents urge creation from scratch.
2. **Faculty incentivization**: There is strong consensus that faculty must be rewarded for commercialization activity — through grants, recognition, reduced teaching loads, or revenue-sharing from licensing. Without this, innovation remains extracurricular.
3. **Industry-academia partnership programmes**: Both regions recommend formal mechanisms for industry collaboration — joint labs, sponsored research, internship pipelines, and industry advisory boards. Nepal emphasizes seed funding from industry; AP emphasizes co-ownership of IP.
4. **Capacity building workshops on IP and commercialization**: Respondents from both regions almost universally support regular workshops. Nepal shows a particularly high interest (68% of respondents) compared to AP (0%).
5. **Government-funded innovation grants**: Both regions call for direct government financial support for green innovation, though Nepal additionally asks for policy frameworks that don't currently exist.

Policy Gaps That Stand Out

The gap between filing and commercialization found in AP represents that many patents are filed but few reach market. Respondents consistently recommend dedicated commercialization roadmaps and legal review committees. Faculty incentives are present in many institutions but perceived as insufficient. Revenue-sharing models and time allocation policies are mentioned. Government's role is seen as facilitative: the AP State Innovation Council and similar bodies are praised but asked to be more proactive in matching researchers with industry. The most critical gap is the absence of a national Green Innovation IP Policy in Nepal. Multiple respondents note that Nepal lacks the legal architecture (patent law for universities, technology transfer regulations) that India has developed over decades. Nepal respondents repeatedly call for government to "simplify licensing", "provide clear IP policies", and "recognize and strengthen educational institutions" rather than simply funding them. There is a striking call for international partnerships — recognizing that Nepal's domestic market is too small to absorb commercialized green technology at scale, respondents advocate for exporting knowledge and partnering with multilateral bodies.

Representative Narrative Insights

AP — Strategy Narratives (Illustrative Snippets) "AP State Council for Science & Technology to provide mentorship, legal advisory support, and funding for green innovation…" "Government Incentives" "Active facilitation by AP State Innovation Council, incentives for IP filing, legal advisory support through university-…" "Government Incentives"
Pattern represents that AP strategy narratives are operationally detailed — respondents know what needs to be done (TTOs, legal clinics, IP roadmaps) and are asking for resources and coordination to do it.
Nepal — Strategy Narratives (Illustrative Snippets) "Promotion and improve" "Establish Technology Transfer Offices, provide seed funding, support IP protection, encourage industry collaboration, an…"
Pattern show that Nepal strategy narratives are more aspirational — respondents want the enabling conditions (policy, legal frameworks, institutional culture) to be created before implementation can begin.

Government Role — AP and Nepal Narratives “Grants, technical assistance, training modules, policy advocacy for IP awareness and commercialization” “Legal framework enforcement, grants, capacity building, structured licensing and commercialization support” “Policy framework, legal advisory boards, incubation support, grants for commercialization, monitoring mechanisms” “Regular policy guidance, grants, workshops, legal clinics, and regulatory oversight to streamline commercialization”
Vision for Commercialization — Nepal show “Understanding green abundance and utilization of it” “Structured support from research to market, strong legal framework, active industry partnerships, and sustainability”
Synthesis: Narrative Archetypes
In AP “The Scaling Challenge**”**: AP institutions have built the foundational architecture for green innovation (R&D Cells, IP Offices, policies) and are now facing the challenge of scaling. Their qualitative narratives reflect the complexity of moving from patent filing to market adoption — a challenge that requires deeper industry integration, better legal support, and more consistent faculty incentives.
Nepal — “The Foundation Challenge”: Nepal institutions are still building the foundation. Their qualitative narratives emphasize the need for basic infrastructure, legal frameworks, policy clarity, and human capacity before commercialization can become a realistic goal. Their responses convey a sense of urgency about systemic reform rather than incremental improvement.
Convergence Point: Both regions agree that green innovation commercialization in higher education requires a three-pillar approach — dedicated institutional structures (TTOs, R&D Cells), enabling government policy (IP law, grants, regulatory clarity), and active industry partnership. The sequencing differs: Nepal needs all three simultaneously as foundational investments; AP needs to deepen each pillar while better connecting them.

Key Comparative Insights
Which Region Performs Better, and Why?
Andhra Pradesh outperforms Nepal across all measurable innovation metrics. The key structural reasons are AP’s near-universal R&D Cell presence (76%) vs Nepal’s (68%) reflects decades of state investment in university innovation capacity, AP benefits from national IP frameworks (the Indian Patents Act, Start-up India, NIRF) that Nepal lacks equivalents of. AP respondents rate their legal framework at 3.41/5 vs Nepal’s 1.76/5 and AP respondents are more commonly report high or medium incentive levels, creating stronger intrinsic motivation for commercialization.
Which Institution Types Are Strongest?

- In **AP**: Central Universities and Deemed Universities drive innovation output; Private Colleges add commercialization reach.
- In **Nepal**: Central Universities (Kathmandu, Tribhuvan) are the primary research engines, with other types showing minimal measurable output.

Biggest Performance Drivers
Based on cross-sectional analysis, the factors with the largest effect on patent output are: 1. Presence of an IP Rights Office (+0.02 patents on average in AP) 2. Presence of an R&D Cell 3. Faculty Incentives (High vs Low incentive institutions show distinctly different patent profiles) Legal Framework Adequacy (higher-rated environments correlate with higher outputs)

Discussion

The statistical analysis provides a clear picture of the green innovation landscape in Andhra Pradesh (AP) and Nepal, revealing deep structural inefficiencies in the transition from research to commercialization. The findings demonstrate that while both regions are engaged in innovation activities, the effectiveness of their innovation systems differs significantly in terms of scale, maturity, and outcomes.
In Andhra Pradesh, the data reflects a relatively strong foundation in research and patent generation. With 68 green projects and 45 patents filed across Andhra Pradesh, the region exhibits a reasonably active innovation ecosystem. The average number of green projects per institution (2.34) and patents filed (1.55) suggests that institutions are not only engaged in research but are also capable of converting research outputs into intellectual property. However, the extremely low commercialization output—only 2 patents—indicates a critical breakdown in the final stage of the innovation pipeline. The commercialization rate of 4.4% and a project-to-commercialization yield of just 2.9% highlight a severe “last-mile” problem. This suggests that the issue is not the absence of innovation, but rather the inability to translate existing innovations into market-ready solutions.
The distribution patterns further reinforce this observation. The right-skewed nature of patent filings indicates that a small number of institutions are responsible for a disproportionate share of innovation output, while the majority contribute minimally. Similarly, the commercialization data shows that only a very small fraction of institutions have successfully brought any innovation to market. This concentration of performance points to systemic inequalities in institutional capacity, access to resources, and support mechanisms. Additionally, the relatively moderate rating of the legal framework (mean of 3.41) suggests that while policies and regulations exist, they may not be effectively operationalized to support commercialization. The gap between legal awareness and practical implementation appears to be a key constraint.

In contrast, Nepal's statistical profile reveals a much earlier stage of development in the innovation lifecycle. With only 17 green projects and 5 patents filed across Nepal, the level of innovation activity is significantly lower than in AP. The average of 0.5 projects per institution and 0.15 patents filed indicates that many institutions are either not engaged in innovation activities or are doing so at a very minimal level. The absence of any commercialized patents further underscores the lack of a functioning innovation pipeline. Unlike AP, where the challenge lies in commercialization, Nepal faces constraints at the very foundation of innovation, including limited research output, low patenting activity, and inadequate institutional capacity.

The legal framework in Nepal emerges as a major limiting factor. With a mean rating of 1.76 and no responses above 2, the data indicates a uniformly weak perception of regulatory support for innovation and intellectual property. This lack of confidence in the legal environment likely discourages institutions from engaging in patenting and commercialization activities. Moreover, the low variability in responses suggests a consensus among respondents regarding the inadequacy of the system, pointing to systemic rather than isolated issues.

A comparative analysis of the innovation pipeline further highlights the divergence between the two regions. Andhra Pradesh demonstrates a relatively high conversion of projects into patents, with a filing rate of 0.66 patents per project, whereas Nepal's rate is significantly lower at 0.29. However, both regions converge at the commercialization stage, where outcomes are negligible. This indicates that despite differences in scale and capacity, both systems ultimately fail to deliver market-ready innovations. The "leakage" observed at each stage of the pipeline suggests that inefficiencies are cumulative and not confined to a single point.

Infrastructure and institutional support structures also play a crucial role in shaping these outcomes. While a majority of institutions in AP report the presence of R&D cells, IP offices, and technology transfer mechanisms, the effectiveness of these structures appears limited, as evidenced by low commercialization outputs. In Nepal, the absence or limited presence of such support systems further constrains innovation activities. The stark difference in IP rights office availability between the two regions highlights the importance of institutional infrastructure in facilitating innovation and protecting intellectual property.

Another important insight from the statistical findings is the discrepancy between perceived and actual performance, particularly in earlier survey versions. The corrections applied in this analysis reveal that prior estimates significantly overrepresented commercialization and innovation activity. This emphasizes the importance of verified data in accurately diagnosing systemic issues and designing appropriate policy interventions.

Overall, the discussion points to a fundamental challenge in both regions: the inability to create a seamless and efficient innovation ecosystem that connects research, intellectual property, and market application. In Andhra Pradesh, the priority should be to strengthen commercialization mechanisms, including industry partnerships, funding for scaling, and legal support for IP monetization. In Nepal, efforts must focus on building the foundational elements of innovation, such as research capacity, policy frameworks, and institutional awareness.

In conclusion, the statistical evidence highlights that green innovation systems in both regions are underperforming relative to their potential. While Andhra Pradesh needs to address inefficiencies in the later stages of the innovation pipeline, Nepal must first establish a functional pipeline itself. Addressing these challenges requires a coordinated approach involving policy reform, institutional strengthening, and enhanced collaboration between academia, industry, and government. Only through such integrated efforts can innovation be effectively translated into sustainable and impactful outcomes.

The comparative analysis highlights a clear disparity between Andhra Pradesh (AP) and Nepal in terms of the scale and maturity of green innovation activities, while simultaneously revealing a shared weakness in commercialization outcomes. AP demonstrates a significantly stronger innovation base, with higher levels of project initiation and patent filing across its institutions. The average output per institution in AP far exceeds that of Nepal, indicating a more active and structured research ecosystem. Statistical comparisons further confirm that these differences are not incidental but are statistically significant, particularly in areas such as patent generation, project activity, and perception of legal frameworks. The presence of institutional support structures, including IP offices and technology transfer mechanisms, also contributes to AP's relative advantage. However, despite this stronger foundation, the actual conversion of research into marketable outcomes remains extremely limited, suggesting that structural inefficiencies persist even within a comparatively advanced system.

In contrast, Nepal's innovation ecosystem appears to be at an early developmental stage, characterized by minimal research output, very low patenting activity, and a complete absence of commercialization. The weak perception of the legal and regulatory environment further constrains innovation efforts, indicating systemic limitations rather than isolated institutional issues. While AP faces challenges primarily in the later stages of the innovation pipeline, Nepal struggles to establish the pipeline itself. Nevertheless, a critical insight from the comparison is that both regions converge at the point of commercialization failure, with negligible outcomes despite differing levels of input. This suggests that the problem is not only about increasing innovation activity but also about strengthening the entire ecosystem, including legal support, institutional capacity, and industry linkages. Therefore, while AP must focus on improving the efficiency of its commercialization mechanisms, Nepal requires foundational reforms to build a sustainable and functional innovation system.

The qualitative analysis reveals a structurally differentiated yet interconnected landscape of green innovation commercialization in Andhra Pradesh (AP) and Nepal. The findings demonstrate that while both regions exhibit institutional engagement with green innovation, the nature and intensity of barriers vary significantly depending on

the stage of the innovation pipeline. The discussion highlights that commercialization challenges are not merely technical or academic in nature but are deeply embedded in legal, financial, institutional, and policy ecosystems.

In the case of Andhra Pradesh, the data clearly indicates the presence of a relatively mature research and intellectual property (IP) generation ecosystem. With a substantial number of green projects and patents already filed, the region has successfully progressed beyond the initial stages of innovation. However, the extremely low rate of commercialization reflects a critical "transfer gap" between knowledge creation and market application. The dominance of themes such as IP/legal challenges, policy gaps, and industry collaboration issues suggests that institutions face difficulties not in generating innovations, but in navigating the complex post-filing landscape. Legal complexities surrounding licensing, lack of structured commercialization pathways, and insufficient industry linkages hinder the translation of patents into viable products or services. This indicates that the innovation ecosystem in AP is supply-driven but lacks the necessary demand-side integration and enabling frameworks to ensure market uptake.

Further, funding constraints emerge as a cross-cutting issue, particularly in the commercialization phase. While initial research funding may be available, there is a noticeable absence of targeted financial mechanisms to support scaling, prototyping, and market entry. This gap is compounded by limited institutional capacity in terms of technology transfer offices (TTOs), legal advisory support, and commercialization expertise. The qualitative narratives emphasize the need for structured institutional mechanisms, including legal clinics, incubation centers, and government-facilitated industry partnerships. These findings suggest that AP requires a shift from a research-centric model to a market-oriented innovation ecosystem, supported by integrated legal, financial, and policy interventions.

In contrast, Nepal's qualitative responses reflect a fundamentally different challenge, characterized as a "pipeline gap." Unlike AP, Nepal has not yet developed a robust foundation for innovation and IP generation. The limited number of green projects and patents indicates that the system is still in its nascent stage. The prominence of themes such as awareness and training gaps, policy deficiencies, and lack of trained personnel underscores the absence of foundational infrastructure necessary for innovation. Respondents consistently highlight the need for capacity building, institutional awareness, and policy support, indicating that the barriers are not related to commercialization per se, but to the initial stages of research, innovation, and IP development.

The lack of a strong policy and regulatory framework further exacerbates Nepal's challenges. Without clear guidelines, incentives, or institutional support for patent filing and commercialization, researchers and institutions are unable to engage effectively in innovation activities. Additionally, weak industry-academia linkages and limited market exposure restrict opportunities for collaborative research and commercialization. This suggests that Nepal's innovation ecosystem requires comprehensive development, starting from awareness creation and training to the establishment of legal and institutional frameworks that support IP generation and protection.

Despite these contextual differences, the analysis identifies several shared challenges across both regions. Funding limitations, inadequate industry collaboration, and gaps in policy implementation emerge as common themes. Importantly, both regions demonstrate a disconnect between academic research and market needs, highlighting the absence of effective mechanisms for knowledge transfer and commercialization. The recurring emphasis on the need for TTOs, faculty incentives, government grants, and capacity-building initiatives indicates a shared recognition of the importance of institutional support systems in bridging this gap.

The findings also underscore the critical role of government in shaping the innovation ecosystem. In both regions, respondents call for proactive government intervention in the form of policy reforms, financial incentives, legal support, and facilitation of industry partnerships. This points to the necessity of a coordinated, multi-stakeholder approach involving academia, industry, and government. The absence of such coordination leads to fragmented efforts and limits the overall impact of innovation activities.

From a broader perspective, the discussion highlights that the challenge of green innovation commercialization is not merely a function of research output but is deeply influenced by systemic factors. The low commercialization rates observed in both regions indicate that innovation systems are not effectively translating knowledge into societal and economic benefits. This has significant implications for sustainability goals, as green technologies remain confined to academic settings without reaching end-users or contributing to environmental solutions.

In conclusion, the qualitative evidence suggests that Andhra Pradesh and Nepal require context-specific yet structurally aligned interventions. AP must focus on strengthening post-filing support systems, including legal frameworks, funding mechanisms, and industry linkages, to bridge the commercialization gap. Nepal, on the other hand, needs to build its innovation ecosystem from the ground up, prioritizing awareness, capacity building, and policy development. At the same time, both regions must address shared systemic issues through integrated strategies that promote collaboration, enhance institutional capacity, and align innovation activities with market and societal needs. Such a holistic approach is essential to transform green innovation from an academic exercise into a driver of sustainable development.

Legal Analysis:

The Andhra Pradesh government provides a range of policies to support green innovation, from granting patents to commercializing the technology. Key initiatives are focused under the state's latest **Innovation & Startup Policy** and **Integrated Clean Energy (ICE) Policy**, with significant backing from central government schemes. AP State government has provided following policies:

Andhra Pradesh Innovation & Startup Policy (4.0) 2024–2029

This comprehensive policy provides incentives to strengthen the innovation ecosystem for startups across all sectors, including green technology. A single-window platform for startups to apply for financial assistance, incubation, and other incentives. This portal handles the entire process for availing incentives under various state policies. This policy reimburses expenses for filing and prosecuting patents:

- **Domestic Patent**: Up to ₹5 lakh per patent.
- **International Patent**: Up to ₹10 lakh per patent.

Startups showing a consistent year-on-year growth rate of 15% are eligible for grants of up to 5% of their turnover. A State Innovation Fund provides capital to venture capital funds that invest in startups, assisting entrepreneurs with seed funding. A 50% subsidy on lease rentals is offered for up to three years to provide startups with ready-to-use office spaces. This policy, a continuation of previous initiatives, explicitly includes "Climate Tech" as one of its focus areas for creating new centers of excellence.

Incentives for green patents and commercialization: The policy aims to support startups in specific emerging technologies, including Climate Tech, which directly relates to green innovation. It establishes a "Hub and Spoke" ecosystem, with the main Ratan Tata Innovation Hub (RTIH) in Amaravati and five regional centers. This infrastructure provides office space, networking opportunities, and mentorship to help startups scale up.The government facilitates capital grants for the hubs and spokes, which in turn support startups. This can include early-stage funding to help with the costs associated with securing and commercializing a patent. The government allocates budgets for various departments (including Environment & Forests, Energy, and Agriculture) to run innovation challenges and hackathons. This provides a clear market opportunity for green innovations by supporting Proof of Concepts (POCs). The Andhra Pradesh Innovation Society (APIS) acts as the nodal agency, assisting startups with the entire process, from initial idea to commercialization.

Andhra Pradesh Integrated Clean Energy (ICE) Policy 2024

This policy is specifically designed to attract green technology investments and accelerate the transition toward renewable energy. It offers strong support for startups and companies with patented clean energy solutions. Offers up to 25% capital subsidy for renewable energy manufacturing projects and provides reimbursement of net State GST (SGST) for certain green energy manufacturers. Facilitates land leasing and purchase for clean energy projects, with stamp duty concessions and exempted land conversion fees. Establishes a university for Green Energy and Circular Economy to build a talent pool and aid technology transfer in the sector and also provides power subsidies to certain green energy sectors for 5–10 years. The New and Renewable Energy Development Corporation of Andhra Pradesh (NREDCAP) serves as the nodal agency for clean energy projects. It facilitates access to land, clearances, and central government incentives.

Central government schemes accessible in AP

Andhra Pradesh-based startups can also access national schemes to assist with patent commercialization.

- **MSME Innovative Scheme**: This national program supports IP creation and commercialization for Micro, Small, and Medium Enterprises (MSMEs). It offers legal and financial assistance for patent filing and commercialization through Intellectual Property Facilitation Centres (IPFCs).
- **Startup India Seed Fund Scheme**: This scheme offers funding to early-stage startups for prototype development, product trials, and market entry, all of which are crucial steps in commercializing a patented technology.
- **Biotechnology Ignition Grant (BIG)**: A grant of up to ₹50 lakh is available for biotech startups and incubators, supporting the conversion of patented biotech green innovations into commercial products.
- **Technology Incubation and Development of Entrepreneurs (TIDE) 2.0**: This scheme supports tech entrepreneurship in areas like Clean Tech. It provides financial and technical assistance to incubators, helping startups leverage patented technologies for market solutions.

The Andhra Pradesh government supports green innovation through comprehensive policies that focus on innovation, startups, and clean energy, with specific incentives for intellectual property (IP) and commercialization. The Andhra Pradesh Innovation and Startup Policy (4.0) 2024–2029 and the Integrated Clean Energy Policy are the primary frameworks guiding these initiatives.

Andhra Pradesh State government policies on patent

Andhra Pradesh does not have a separate state-level patent Law, its policies and incentives align with the national framework to support innovators. Although not specified in the most recent policies, previous national and state startup policies have included incentives to support patent filing costs for startups and MSMEs. The broader startup ecosystem fostered by APIS is designed to create an easier environment for innovators. This includes support in navigating the IP landscape and connecting with relevant experts for commercialization and licensing agreements. Both the startup and clean energy policies emphasize collaboration between academia and industry. This facilitates the transfer of technology and IP from research institutions to commercial ventures

1. Direct Patent-Related Incentives

- **Electric Vehicle (EV) Policy:** The older Andhra Pradesh EV Policy 2018 (which is being replaced by the Sustainable Electric Mobility Policy (4.0) 2024-29) specifically mentions R&D Grants and financial assistance for patent-related costs:
  - Financial Assistance for Patent Registration: The government provides financial assistance for obtaining patent registration.

- Financial Assistance for Quality Certifications: It also provides assistance for obtaining patent quality certifications.

- **Innovation & Startup Policy:** The Andhra Pradesh Innovation & Startup Policy (4.0) 2024-2029 aims to create a robust ecosystem for innovation. While it doesn't explicitly single out "green patents," it facilitates shared services for startups, including **Patents**, which can be utilized by green technology innovators.

2. Policies Supporting Green Technology (The Subject of Green Patents)

The state is heavily promoting clean energy, which would be the core focus of most green patents. These policies create a high-demand, high-incentive market for green technologies:

- Integrated Clean Energy (ICE) Policy 2024: This policy is a major initiative to transform the state into a global clean energy hub, targeting 160 GW of renewable energy capacity. It provides significant incentives for manufacturing clean energy technologies:
  - Capital Subsidies: Up to 25% of fixed capital investment for manufacturing solar, wind, and electrolyzer (Green Hydrogen) technologies.
  - Tax Reimbursements: 100% reimbursement of SGST (State Goods and Services Tax) for various clean energy products.
- Green Hydrogen & Green Ammonia Policy: This policy focuses on attracting investments in these critical green technologies, offering capital subsidies and infrastructure support.

In summary, while there isn't a dedicated "Green Patent Policy" in Andhra Pradesh, the government does offer specific financial assistance for patent filing under its EV policy, and its Clean Energy policies create a highly incentivized market for the very technologies (innovations) that would be protected by green patents.

Lacunas in Andhra Pradesh's Policy Framework for Green Patents

- **Lack of a Dedicated "Green Patent" Policy-** Patent incentives are scattered across the Innovation & Startup Policy (for all startups) and the EV Policy (for one sector). There is no single, ring-fenced scheme with specific, higher incentives for technologies classified as "green" (e.g., in waste management, water conservation, sustainable agriculture, etc., beyond just EV/RE).
- **Reliance on Central Government's Fast Track-** The primary fast-track for green patents is a Central Government (DPIIT) initiative. The State policy does not add its own administrative layer to actively expedite the state-level processing (e.g., subsidy disbursement, clearances) for green-patented technology, leading to potential bureaucratic delays.
- **Limited Scope of Financial Reimbursement-** The existing IP reimbursement (e.g., 80% rebate for startups) is general. It often only covers the statutory filing fee and may not cover the high cost of professional legal/patent drafting fees, which is the biggest cost barrier for individual inventors and small startups.
- **Absence of a "Commercialization Bonus"-** The policy focuses heavily on investment subsidies for manufacturing (e.g., under the ICE Policy) but does not directly reward the initial inventor/researcher who secured the patent for its societal impact or successful licensing/commercialization.
- **Lack of Defined Green Technology List-** While the ICE Policy is clear on Renewable Energy (RE) and Green Hydrogen, other critical areas of green technology (e.g., advanced wastewater treatment, eco-friendly construction materials, or specialized agri-tech for climate resilience) lack a clear classification for enhanced state incentives for their patented innovations.

Suggested Steps to Improve and Strengthen Green Patent Policy

To position Andhra Pradesh as a true "Clean Energy and Innovation Hub," the state should consolidate and amplify its IP incentives with a dedicated focus.

1. There should be a dedicated "AP Green IP Fund" under the AP Innovation Society (APIS). This fund should offer a higher percentage of reimbursement for all costs (filing, legal, search fees) for patents falling under the WIPO Green Inventory categories, going beyond the general Startup Policy. For example, offer 95% reimbursement (up to a ceiling) for all costs associated with a green patent for a period of five years.
2. There should be a "Green Patent Clearance Window" on the AP Startup One Portal. Any enterprise that has filed for an expedited patent at the Central level (by proving their invention is green) should automatically qualify for priority processing of all related state incentives (like subsidies, approvals, and quality certification reimbursement) under the ICE and Startup policies. This reduces the time-to-market dramatically.
3. There should be an Institute for non-dilutive grant for successful patent commercialization. It should offer a one-time Green Commercialization Grant of ₹5-10 lakh to the patent holder (individual or startup) upon demonstrating two conditions:

1. The green patent has been granted by the Indian Patent Office.
2. The technology has been successfully licensed or adopted by an AP-based industrial or manufacturing unit (verified by a sale/licensing agreement). This directly links the IP incentive to economic outcome.

4. There should be Officially list "Green Patent Thrust Sectors" in the operational guidelines of the ICE and Startup policies. The list should include:
   - Circular Economy/Waste: Patented innovations in plastic recycling, solid waste-to-energy, e-waste management.
   - Sustainable Water: Patented low-cost desalination/purification technologies.
   - Climate-Resilient Agri-tech: Patented solutions for water-efficient irrigation or soil carbon sequestration.

General summary of IP and Commercialization Policies in various universities of Andhra Pradesh

Most universities, whether government, private, or deemed, follow general IP policies that apply to all innovations equally.

- Revenue Sharing: A common policy across many universities is a revenue-sharing model between the inventor and the institution. For instance, Andhra University (AU)**'s** policy specifies that the inventor receives **70%** of the revenue generated from licensing and royalty, while the university retains **30%**. The university may also accept equity in startups in lieu of direct fees.
- IP Ownership: Generally, the IP rights lie with the university once a patent is granted, with the inventor retaining the right to a significant share of the commercial benefits.
- Funding for IPR Centers: Universities often allocate internal funds or receive grants (e.g., from the Rashtriya Uchchatar Shiksha Abhiyan (RUSA) scheme or the Ministry of Commerce and Industry) to establish and operate IPR Cells or Centres for IPR, which facilitate the patent filing process for faculty and students.
- Innovation & Startup Promotion: The broader state environment, influenced by the Andhra Pradesh Innovation & Startup Policy (4.0) 2024-2029, encourages universities to foster startups and innovation ecosystems. University policies generally support the formation of spin-off companies by inventors to commercialize their work.
- Evaluation Process: Policies typically require inventors to submit an invention disclosure form, which is evaluated for novelty, patentability, and market potential by the university's IPR cell.

State Government Funding and Incentives

At the state government level, policies primarily target the deployment and manufacturing of clean energy technologies, rather than the university-led patenting process itself.

- Capital Subsidies: The Andhra Pradesh Integrated Clean Energy (ICE) Policy offers significant capital subsidies. For example, up to **25%** of fixed capital investment for solar, wind, and electrolyzer manufacturing is available.
- Tax Reimbursements and Exemptions: The policy includes 100% SGST (State Goods and Services Tax) reimbursement for a specified period and exemptions on various charges like electricity duty and intra-state transmission charges for clean energy projects.
- Viability Gap Funding (VGF): The government provides VGF or capital subsidies (e.g., **20%** for pilot projects) for the initial demonstration and pilot projects of clean technologies to de-risk them for wider adoption.
- Land Incentives: The state facilitates land acquisition for clean energy projects through long-term leases (up to **30 years**) at subsidized rates and grants deemed non-agricultural status to the land, waiving conversion fees.

Summary of Funding and Commercialization Avenues

Policy	Funding Source	Commercialization mechanism	Green Tech Specific
University IP Policy	IPR Cell funds, RUSA grants, MoCI grants, revenue sharing	Licensing, royalties, university spin-offs (startups)	General; applies to all patents equally
State ICE Policy	State government budget, NREDCAP	Capital subsidies, tax incentives, land leases, VGF for projects	High; specific to clean energy generation/manufacturing

In essence, while the state government provides robust incentives for the implementation of green technologies, the university-level policies currently lack specific provisions that prioritize patenting green innovations over other types of inventions.

Lacunae in Existing Green Patent Policies

- **Absence of Dedicated "Green" Policies:** Most universities, such as Andhra University (AU), have general IP (Intellectual Property) and Innovation/Startup policies. There is a lack of specific, dedicated policies that explicitly prioritize, define, and promote "green" or environmentally sustainable technologies (ESTs) for patenting and commercialization.
- **Generic IPR Framework:** Existing IP policies generally cover all inventions equally, regardless of their environmental impact. This means there are no specific incentives, faster processing, or reduced costs built into the university system for eco-friendly innovations, unlike general patent facilitation.
- **Limited Mandate for Sustainability Research:** While universities are increasingly adopting sustainable campus practices (e.g., waste management, energy efficiency), their core IP policies do not explicitly mandate or provide a framework for research to focus on developing scalable green technologies for broader societal use.
- **Barriers to Access and Commercialization:** General challenges in the Indian patent ecosystem, such as legal inconsistencies and barriers to technology transfer, also apply to green patents. University policies often do not have specific mechanisms to overcome these barriers for green innovations, such as streamlined licensing or technology transfer agreements with green industry partners.

- **Lack of Clear Definition and Classification:** University policies rarely define "green patents" using established international classifications (like the WIPO IPC Green Inventory or CPC codes), making it difficult to track, monitor, and incentivize the creation of such patents specifically.

Recommendations for Strengthening the Policies

To strengthen green patent policies in universities of Andhra Pradesh, the following steps are recommended:

- **Adopt Specific Green Patent Policies:** Universities should develop and adopt specific, dedicated "Green Patent Policies" that align with state-level energy conservation and climate change mitigation goals. These policies should explicitly define green technologies based on WIPO or European Patent Office (EPO) classifications.

Provide Financial and Infrastructural Incentives:

- o **Subsidized Patenting:** Offer reduced or fully subsidized patent filing and maintenance costs for inventions classified as green technologies.
- o **Dedicated Green Funds:** Establish dedicated "Green Innovation Funds" to provide seed funding for research, prototype development, and commercialization of sustainable technologies.
- o **Green Incubation Centers:** Set up specialized incubation centers focusing solely on green startups and innovations, providing them with technical expertise and market access support.

- **Streamline Commercialization of Green Tech:** Implement streamlined, fast-track licensing processes for green patents, possibly with more favorable royalty terms (e.g., lower university share of royalties) when licensed to green startups. This encourages faster deployment of these crucial technologies to the market, addressing the "green patent paradox" where valuable technology sits unused.
- **Integrate IPR and Sustainability into Curriculum:** Make IPR and sustainability a mandatory credit course for relevant engineering and science students, encouraging a culture of green innovation from the academic stage.
- **Foster Collaboration and Networking:**
- o **Industry Partnerships:** Actively facilitate research collaborations and partnerships with green industry players to align university research with real-world needs and market demands.
- o **International Collaboration:** Encourage researchers to collaborate with international organizations like WIPO Green, which facilitates the sharing and licensing of green technologies.
- **Establish Monitoring and Reporting Mechanisms:** Implement robust monitoring systems to track the number of green patents generated, their impact, and commercialization success, using these metrics to inform future policy adjustments. The state nodal agency role played by institutions like Andhra University could be expanded to coordinate this across all state universities.

Conclusion

In conclusion, the study clearly demonstrates that while higher education institutions play a crucial role in generating green innovations, the transition from research to commercialization remains significantly constrained by legal, institutional, and financial barriers. The comparative analysis between Andhra Pradesh and Nepal highlights that the presence of structured research ecosystems, supportive legal frameworks, and institutional mechanisms such as R&D cells and IP offices substantially influence innovation outcomes. However, even in relatively advanced settings like Andhra Pradesh, the gap between patent generation and commercialization persists, indicating the need for stronger industry linkages, streamlined legal processes, and enhanced incentives for researchers. The findings underscore that effective commercialization of green innovations requires an integrated approach combining robust policy support, institutional capacity building, and active collaboration between academia, industry, and government. Strengthening these interconnected pillars will not only accelerate the market adoption of sustainable technologies but also contribute meaningfully to environmental sustainability and economic development.

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