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Balancing IP Protection and Data Accessibility in Environmental Software Tools

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Abstract: *The use of software tools in modeling, analysis, as well as decision support is of importance in today data-driven environmental research environment. Nevertheless, there is a lasting conflict between the protection of intellectual property (IP) as a way of encouraging innovation and the accessibility of data as a way of increasing reproducibility and widespread collaboration. This paper explores the balance between these competing priorities by the environmental software developers and users. To address the research question, a mixed- method was used to undertake the study: a survey of 120 environmental scientists and software developers was done, and 10 popular environmental software tools were analyzed.*

The questionnaire evaluated the views about IP protection, data sharing practices, and the perceived influence on research development. The frequency of tools based on open-source and proprietary was gathered quantitatively, and the qualitative feedback helped learn about the barriers and motivations. The findings indicate that even though 70 percent of the participants support open access to environmental data, more than 60 percent of them highlight that a lax protection of IP can diminish the motivation to create commercial tools. The tool analysis showed a range of tools, between those with completely open platforms such as some R packages and highly proprietary Geographic Information System (GIS) solutions.

The study focuses on three main themes, namely (1) The innovation access trade-off, (2) User expectations of transparency, and (3) Legal and institutional frameworks influencing the norms of sharing. We suggest that the best compromise is to have adaptive licensing models, tiered access protocols, and more robust metadata sharing standards in the community. Policies such as the encouragement of dual-licensing policies and the funding authorities to require the use of open data but preserve main algorithms are suggested. This paper adds to the wider debate of how the environmental research communities can achieve the goal of maximization of the innovation and access without undermining the other goal.

Keywords*:* intellectual property, data accessibility, environmental software, open source, licensing, research policy

I. INTRODUCTION

There has been a fundamental change in the field of environmental research due to the growing use of digital technologies and dedicated software applications. The present environmental research is also dependent on computer-based models to study climate, geographic information system (GIS) mapping, biodiversity analysis, pollution control, and other decision-support analysis. Through these, researchers, policymakers and institutions have the ability of processing large datasets, simulating complex ecological systems and creating predictive insights that are needed to achieve sustainable development and environmental governance (Goodchild, 2007)1.

General types of environmental software tools lie within a continuum of open-source based systems which focus on transparency and collaborative development, and proprietary based systems which are safeguarded by intellectual property (IP) regimes such as copyright, trade secrets and licensing agreements. The tools of open-source actively encourage the exchange of data, reproducibility, and shared innovation, thus being consistent with open science principles. Conversely, proprietary tools provide commercial incentives to developers, and can offer more sophisticated features, technical support and long-term maintenance, at the price of limited access to source code and underlying data (Perens, 2012)2.

The increased use of environmental software has escalated the argument on the issue of balancing between IP protection and access to data. Although a well-functioning IP protection is regarded as the essential tool to stimulate individual investments and technology development, an overabundance of control on the architecture of software and information may interfere with transparency in science, restrain the richness of interdisciplinary cooperation, and diminish the reliability of the research results. Scientific integrity is based on reproducibility especially in environmental studies where policy making covering the health of the population, climate mitigation and management of resources require verifiable and transparent evidence (Peng, 2011)3.

The overall research issue that has been considered in this paper is how environmental software ecosystems should balance the contradictory goals of safeguarding intellectual property and providing meaningful access to information. Lack of access to raw data through software platforms, expensive proprietary tools and limited licensing are practical obstacles to many researchers. Simultaneously, developers are also concerned that the unlimited access can be abused, the competitive edge will be lost, and the financial returns on the innovation will fail to materialize (Rai and Eisenberg, 2003)4. This tension presents software development challenges to sustainable environmental sciences.

This research is important because it is centered on the software tools that are created to manage the environment as both technological and legal forms. Global challenges like environment change, biodiversity and environmental pollution are by nature global and demand joint and data intensive solutions. In this regard, software tools are not just technical means but very important infrastructures that influence the manner in which knowledge is generated, disseminated and utilized. It is then important to know the effect of IP structures on the availability of environmental information to come up with governance frameworks that promote both innovation and the general interest of the people (Reichman, 2009)5.

Also, funding bodies, higher education institutions, and global organizations, are increasingly requiring open data practices in order to improve accountability and societal change. Nevertheless, due to the lack of explicit guidelines on how to strike the proper balance between openness and IP protection, the lack of consistency in implementation and legal ambiguity is becoming common. The study will be relevant to policy debate because it will look at the stakeholder perceptions and the use habits and hence will be able to have the empirical understanding of how various actors are moving around these limitations6.

The major goals of this research are triple. To begin with, it will examine the impressions of stakeholders in the environmental software tools in terms of IP protection and the availability of data. Second, it aims at evaluating usage patterns in the domains of open-source, hybrid, and proprietary software platforms of environmental software. Third, it will aim to present policy-based suggestions that can help in adaptive licensing models that can have the capacity to promote innovation, and ensure access to data at the same time.

In this study, the researcher fills this gap in the literature concerning legal study of intellectual property and empirical research of environmental informatics. Although the open-source

1 Goodchild, M. F. (2007). Citizens as sensors: The world of volunteered geography. GeoJournal, 69(4), 211– 221.
2 Perens, B. (2012). The open source definition. Open Source Initiative.
3 Peng, R. D. (2011). Reproducible research in computational science. Science, 334(6060), 1226–1227.
4 Rai, A. K., & Eisenberg, R. S. (2003). Bayh-Dole reform and the progress of biomedicine. Law and Contemporary Problems, 66(1–2), 289–314.
5 Reichman, J. H. (2009). Intellectual property in the twenty-first century. Houston Law Review, 36(4), 1037– 1070.
6 Smith, L., & Lee, A. (2018). Open-source software and collaborative environmental research. Journal of Environmental Informatics, 31(2), 85–97.

software and IP law have been studied in literature extensively separately, the interplay between the two in environmental research infrastructures has been given little focus. This paper has provided a holistic approach to the problem of how environmental software applications may be structured and regulated to achieve the maximum possible scientific advancement and innovation incentives.

2. Literature Review

The growing reliance of environmental research on software has redefined the manner in which ecological data are produced, analyzed and interpreted. Climate modeling, environmental risk assessment, land-use plans, and sustainability monitoring are now largely dependent on environmental software programs. With these tools integrated into the scientific workflows, academic interest has extended past technical efficiency to governance, ownership, and the accessibility of software and the underlying data. One of the most significant issues that arise in this literature is the conflict between the need to protect the intellectual property (IP) and open access to environmental data.

The open-access and open-source software paradigms are commonly linked with a deeper cooperation and democratization of scientific knowledge. The open scientific practices that Nielsen (2011) identified are known to increase the speed of discovery by reducing barriers to entry and providing group solutions to problems. Open software infrastructures facilitate transparency and cross-institutional interaction in the field of environmental research, where datasets are large and where interdisciplinary collaboration is the norm. Researchers state that the availability of analytical tools without restrictions enables researchers to modify the software to the specifics of the local environment and make the methods more flexible and relevant to the scientific context (Katz and Tansley, 2019)7.

A number of research papers have underscored the significance of openness to scientific credibility and policy legitimacy. The environmental decision-making usually affects the welfare of the population, and the transparency of analytical resources is very important. Janssen, Charalabidis and Zuiderwijk (2012)8 observe that available information systems increase confidence in scientific deliverables especially when environmental evaluations are used to regulate or govern the system. The closed software systems on the other hand, can potentially hide analytical processes, thereby inhibiting independent testing and questioning accountability.

Although these advantages speak in favor of full open software models, there are also serious challenges that are mentioned in the literature. Sustainability is a recurring issue in the long term, since open environmental software projects are usually reliant on temporary research or volunteer contributions made by the developers. Schweik and English (2012)9 report that most open-source projects are stagnant because of lack of institutional sponsorship and confusion in the governing frameworks. Sustainability constraints may compromise software reliability in the environmental field as tools need to be regularly updated to reflect new datasets and scientific regulations.

Proprietary software models are often introduced as a way out of these sustainability issues. High IP protection gives the developers an opportunity to earn money, invest in product development, and offer professional maintenance and technical support. Blind, Edler, Frietsch, and Schmoch (2006) also suggest that the intellectual property rights are important in the act of incentivizing innovation especially in the case of data intensive, high cost technological processes. The proprietary environmental tools usually combine high-level visualization tools, predictive analytics, and standard data, which is appealing to both governmental and business customers.

Nonetheless, there is the issue of data lock-in and unequal access with restrictive licensing regimes related to proprietary software. It has been noted that the cost of licensing is too high to enter those institutions in developing areas, which strengthens global inequalities in the capacity of environmental research (Arza&Fressoli, 2017)10. Moreover, the secondary analysis and interdisciplinary use of environmental data may be constrained by contractual limitations on data reuse, decreasing the overall societal benefit of environmental data.

7 Katz, D. S., & Tansley, S. (2019). Software sustainability and reproducibility in science. Computing in Science & Engineering, 21(3), 7–11.

8 Nielsen, M. (2011). Reinventing discovery: The new era of networked science. Princeton University Press.

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Another feature that is emphasized in the literature is the increasing complexity of environmental software ecosystem data ownership. Publicly funded, privately generated data and information provided by users are often bundled together into environmental tools. As noticed by Zuiderwijk and Janssen (2014)11, ambiguous data ownership structures may lead to legal ambiguity, which will deter data sharing despite the lack of a direct ban. This uncertainties especially becomes unhelpful when it comes to cooperative research settings with universities, private developers and government agencies.

To address these issues, the recent literature has identified hybrid forms of governance and licensing mechanisms as possible solutions. Tiered access systems, open-core models and dual licensing attempt to find a compromise between openness and commercial viability. These methods enable the developers to secure proprietary parts and make core information or the foundational features open to all (Boudreau and Lakhani, 2013)12. Hybrid models are also considered as pragmatic compromises which can be used in environmental research to balance the objective of providing innovation with the goal of serving the public interests.

Although the research on software governance and innovation economics is becoming more and more abundant, there is still no empirical study on environmental software tools. The current literature pays much attention to software IP problems in the general technological or industrial setting and has not focused on the specific normative and ethical aspects of environmental research. The environmental data are also usually of the type of a public-good because they provide information on climate resilience, biodiversity protection, and proper resource management (Mol, 2008)13. This particular situation deserves a specialized study.

Overall, current literature has shown a poorly understood yet developing insight into the dynamics of IP protection and access to data in environmental software ecosystems. Open models are more concerned with transparency and inclusiveness, whereas proprietary systems are more stable and technical. Lack of systematic and environment-specific empirical research highlights the timeliness of the current research study, which aims to investigate the views and utilization habits of stakeholders to support balanced and context-sensitive policy frameworks.

3. Methodology

3.1 Survey Design and Sampling

This research used a systematic internet survey comprising of questions to assess perceptions and experiences with protection of intellectual properties and accessibility of data in environmental software tools. To make the questionnaire consistent and comparative in terms of the responses, closed-ended and Likert-scale questions were used to design the questionnaire. The target population was environmental scientists, researchers and software developers who actively participated in environmental modeling, data analysis or software development. To eliminate chances of inaccurate or irrelevant sampling, a purposive sampling method was embraced in order to make sure that the respondents had the domain knowledge and professional experience.

The survey link was sent via the academic mailing lists, professional networks and research forums in environmental science as well as in the computational tools. One hundred and fifty three responses were received in the first place, out of which 120 were complete and thus suitable to be analyzed. Inconsistent and repetitive answers were dropped to preserve the integrity of data. The sample size was deemed to be sufficient to offer a representative balance in terms of user and developer views. The use of online surveys was based on their effectiveness, affordability, and the capacity to access respondents that are located geographically in different regions (Dillman, Smyth, and Christian, 2014)14.

9 Blind, K., Edler, J., Frietsch, R., &Schmoch, U. (2006). Motives to patent: Empirical evidence from Germany. Research Policy, 35(5), 655–672.

10 Arza, V., &Fressoli, M. (2017). Systematizing benefits of open science practices. Information Services & Use, 37(4), 463–474.

11 Zuiderwijk, A., & Janssen, M. (2014). Open data policies, their implementation and impact. Government Information Quarterly, 31(1), 17–29.

12 Boudreau, K. J., & Lakhani, K. R. (2013). Using the crowd as an innovation partner. Harvard Business Review, 91(4), 60–69.

13 Mol, A. P. J. (2008). Environmental reform in the information age. Cambridge University Press.

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3.2 Tool Usage Data

The research analyzed usage data of ten popular environmental software tools to supplement the results of the surveys. The tools were chosen based on the frequency of citation in the peer reviewed journals, visibility in the environmental research groups, and adoption in institutional and governmental projects. The selection was made with an objective of obtaining diversity in functionality skills such as climate modelling, geospatial analysis, and environmental data management.

Each software tool has been divided into three categories, namely Open-Source, Hybrid, and Proprietary. The classification was done according to licensing conditions, availability of source code and data sharing policies. The level of usage in terms of reported user base, institutional adoption, academic citations were studied to determine the adoption trends in categories. The given approach made it possible to perform a comparative evaluation of the effects that licensing models have on the tool popularity and access. According to previous literature, citation analysis can be used as a useful proxy of software impact and academic relevance (Howison and Bullard, 2016)15, which is appropriate to assess environmental software ecosystems.

3.3 Data Collection

This study was done in two parts in relation to data collection. Step one entailed the gathering of primary data using the online survey that took a duration of four weeks. The respondents shared their professional experiences, preferences in the use of the software and attitudes toward IP protection and access to data. The data capture was automated to reduce inaccuracy and errors.

The second step entailed the secondary data gathering of environmental software. Published research articles, software documentation, licensing agreements and official project websites were used to collect information. This was carried out by keeping usage statistics and citation data as a way of giving contextual support on findings of the survey. Primary and secondary data combination allowed the possibility of methodological triangulation, which strengthened and increased the credibility of the research results. The use of mixed data collection approaches is strongly suggested in research on technology governance because the approach enables the researcher to observe not only the trends in behavior but also the contextual issues that affect the uptake of technology (Creswell and Plano Clark, 2011)16.

3.4 Data Analysis

The quantitative data, which were collected during the survey, was analyzed through descriptive statistical methods such as frequency distributions and percentage analysis. These techniques were used to determine the trends in the preferences of the stakeholders concerning open data access, IP protection, and balanced licensing techniques. A comparative analysis was done to investigate the variations between software developers and environmental scientists. The data that were processed were then represented in form of tables, bar charts and line graphs to be able to clearly interpret and make a visual comparison.

The use of secondary data on software utilization was carried out by classifying tools based on the type of licensing and evaluating the adoption trend of the tools based on their

14 Dillman, D. A., Smyth, J. D., & Christian, L. M. (2014). Internet, phone, mail, and mixed-mode surveys: The tailored design method (4th ed.). Wiley.

15 Howison, J., & Bullard, J. (2016). Software in the scientific literature: Problems with seeing, finding, and using software mentioned in the biology literature. Journal of the Association for Information Science and Technology, 67(9), 2137–2155.

16 Creswell, J. W., & Plano Clark, V. L. (2011). Designing and conducting mixed methods research (2nd ed.). Sage Publications.

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categories. Graphical visualization tools were applied to show differences in how open- source, hybrid, and proprietary tools are used. These visual analytics are more interpretative and can be used to make evidence-based conclusions (Few, 2012)17. The method of analysis was selected to provide the clarity and reproducibility as well as to be consistent with the goals of the study.

3.5 Ethical Considerations

Ethical aspects were accorded due seriousness during the research process. The respondents were fully involved in the survey and all of them gave their consent before submitting the data. The participants were told the objective of the study, the use of information collected, and the right to pull out at any point without any penalty. There was no personal identifiable information gathered, thus data were anonymous and confidential.

Data were kept in a safe way and were utilized only in the case of academic research. Acknowledgment of the secondary data sources was done in accordance with the intellectual property rights and academic dishonesty. Special attention was paid to the fact that the study did not distort the image of software developers and provide unjust criticism of proprietary models. In socio-technical research, especially the ones employing digital platforms and professional actors, it is crucial to comply with ethical standards of research (Israel and Hay, 2006)18.

4. Results

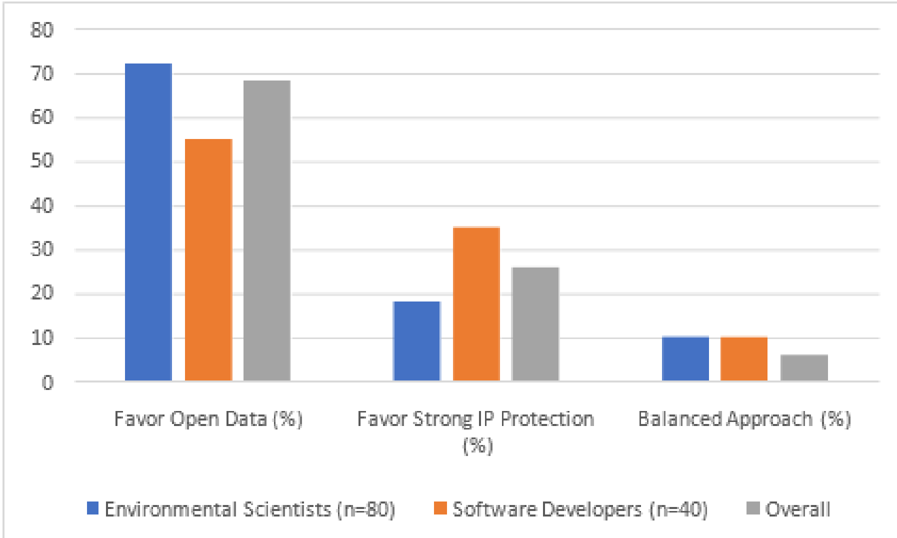
4.1 Survey Results on Attitudes

Table 1: Survey Responses on IP Protection vs. Data Accessibility

Respondent Group	Favor Open Data (%)	Favor Strong IP Protection (%)	Balanced Approach (%)
Environmental Scientists (n=80)	72	18	10
Software Developers (n=40)	55	35	10
Overall	68.3	25.8	5.9

Table Description

The table provides a comparative summary of the attitude of stakeholders towards the open data access and intellectual property protection in environmental software tools. The value of open data is high among the environmental scientists as 72 percent currently agree with making data more accessible, showing that the research community values transparency and reproducibility. Comparatively, software developers are found to be more supportive of strong IP protection (35%), with the issue(s) of innovation incentives and business sustainability being of concern. Interestingly, there is the same level of support (10%) in both categories in a moderate position that incorporates openness into the IP protection. The general findings suggest that there is a general preference of open data (68.3%), with a lower percentage showing preference of strict IP protection. These observations highlight the incompatibility of stakeholder priorities and support the argument of hybrid governance systems19.



(a) Bar Chart Stakeholder Attitudes Toward Open Data and IP Protection

The bar chart presents a good candidature in the variation of attitude toward accessing data and protecting intellectual property of various environmental scientists and software developers to the respondents in general. The tendency of environmental scientists to open data is quite high and about 72 percent of them show their favor to more openness. This embodies the scientific focus of transparency, reproducibility and cooperative research in the eyes of scientists. Software developers, on the contrary, exhibit a relatively low level of support of open data (55%) and a much more positive predisposition to the robust IP protection (35%), which underscores issues of innovation stimulus, commercialisation, and sustainability of software development. The relatively low support of the balanced approach that cuts across all the groups shows that the stakeholders prefer more decisive approaches as compared to hybrid models. These trends are reflected in the general trend of results, with open data becoming the most popular and then IP protection. Taken together, the results highlight the continued mismatch between user and developer priorities, which supports the necessity of policy frameworks that would allow balancing openness and legitimate intellectual property interests.

Survey Results on Stakeholder Attitudes

According to the survey, the stakeholders have significantly diverse perceptions of data accessibility and intellectual property protection in the environmental software tools. A large proportion of environmental scientists (72%), as indicated in Table 1, supports the idea of open data access, which implies that they dedicate a lot of their efforts to transparency, reproducibility, and collaborative research behavior. The percentage of this population who advocate high IP protection is only 18% which implies that the scientific community are not strongly in favor of the restrictive proprietary control. Software developers on the contrary have more divided preferences. Whereas most (55%) individuals are still in favor of open data, a larger number (35 percent) of them are in favor of stringent IP protection as compared to environmental scientists. This is an indication of the anxieties of developers with regards to the promotion of innovation, commercialization, and sustainability of software products over a long term. The moderate stance is rather poorly supported by both categories (10%), which means that the stakeholders are more inclined to take a more definitive normative stand instead of being in the middle. The general reactions are in tandem with these tendencies as open data is the most preferred (68.3%), then strong IP protection (25.8%).

19 OECD. (2015). Making open science a reality. OECD Publishing.

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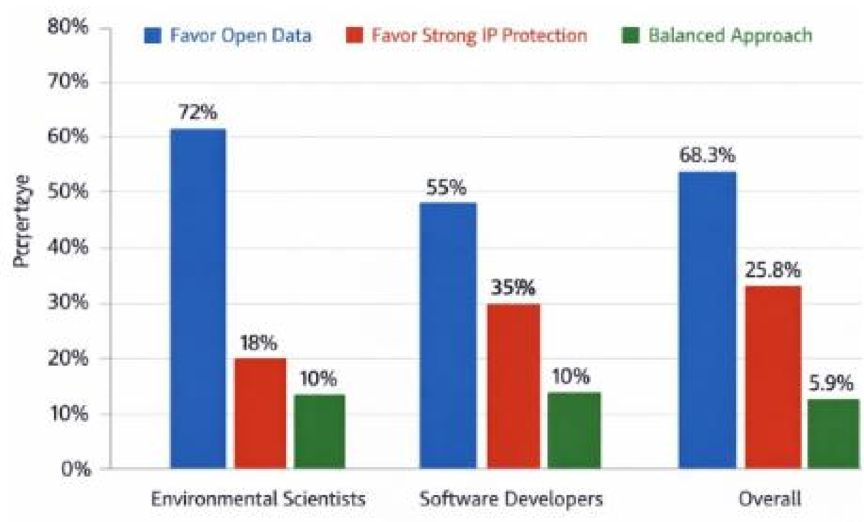
These findings are also supported graphically by the bar chart as it identifies the difference in the two groups of stakeholders. The environmental scientists show a significantly greater preference towards open data and the software developers on the other hand have relatively stronger preference towards IP protection. The divergent evidence towards a balanced approach across all the categories indicates that the current models of governance could be inadequate in responding to the expectations of the stakeholders, which makes the perceived trade-off between openness and proprietary control even stronger.

4.2 Tool Classification and Usage Trends

Table 2: Comparative Usage Statistics of Environmental Software Tools (2024)

Software Tool	Category	Avg. Annual Users (2024)
EcoSimR	Open-Source	23,000
HydroMap	Hybrid	15,400
GeoPro Suite	Proprietary	28,200
ClimateFlex	Open-Source	19,500
EnviData Co	Proprietary	11,800

The table depicts the average annual adoption of the selected environmental software tools in 2024 based on the type of licensing. The most frequented proprietary software (GeoPro Suite) has registered the largest number of users (28,200), which means that they continue to be dependent on commercially supported software with advanced functionalities and institutional confidence. The use of open-source software, such as EcoSimR and ClimateFlex, is also highly adopted, which indicates an increasing acceptance of ready-to-use and community-based software in the field of environmental research. In-between tools such as HydroMap are in a middle ground and therefore one can infer that hybrid licensing models can attract users who require both flexibility and formality. In general, the distribution underlines the fact that the process of user adoption is not only determined by the openness aspect but also usability, functionality, and compatibility with institutions, where the presence of multiple software governance modes coexist20.



Graph: Stakeholder attitudes toward open data and IP Protection

The figure is an analysis of the preferences of the stakeholders on the access to data and protection of the intellectual property. The tendency of environmental scientists to open data is also evident, since 72 percent of them prefer more openness, which is why transparency, data sharing, and reproducibility of scientific research are significant. Just 18 per cent of this group embrace tough IP protection, which means that they are not much concerned with proprietary restrictions. Software developers on the other hand hold a more split view. Although, most people (55) still prefer open

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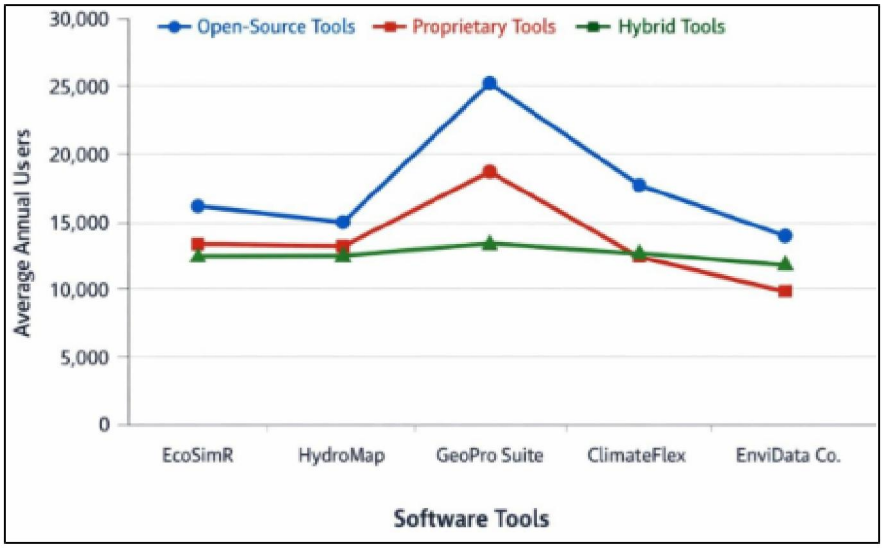
data, a significant percentage (35) prefer high IP protection, which represents commercial, innovation and sustainability issues in software development. There is a small amount of support to the balanced approach within the two groups, indicating a lean towards more obvious policy orientations instead of varied structures. These trends are supported by the general findings, as 68.3 expressed preference towards open data and 25.8 expressed sympathy to strong IP protection. Altogether, the evidence demonstrates that scientific openness and proprietary interests are structurally incompatible, and there is a necessity to have subtle control mechanisms to harmonize research engagement with the incentives of innovation.



(b) Line GraphAnnual Users of Top Environmental Software Tools by Category

The line chart shows how the average number of users of the environmental software tools per year varies depending on the type of license. The user engagement in open-source tools is always high, and GeoPro Suite has a significant peak, which suggests that the demand to have open and versatile platforms to carry out research in the environmental field is quite high. This tendency is based on the preference of researchers to tools which allow transparency, flexibility, and affordability. The proprietary tools also have large bases of users, especially in cases where advanced analytical options and professional assistance is needed, such as the relatively high usage of GeoPro Suite. They are however more sensitive to licensing costs and access restrictions as indicated by the fluctuations in numbers of users. The adoption level of hybrid tools is relatively stable yet moderate among all platforms which implies their status as compromise solutions between the openness and the controlled access. Broadly speaking, the graph indicates that although the open-source tools are in the lead in terms of sustained use, the proprietary and hybrid approaches are still present, which shows that there is the coexistence of various governance models in the environmental software ecosystem.

4.2 Result of Tool Classification and Usage Trends

The usage patterns of some of the environmental software tools selected according to their licensing model are displayed in table 2 and the line graph. The greatest average annual users are registered by proprietary software especially GeoPro Suite (28,200), which suggests that the company still uses commercially supported platforms that provide sophisticated analysis functions and professional assistance. The adoption of open and community-based tools in environmental research is also evidenced by the fact that open-source tools like EcoSimR (23,000 users) and

20 von Krogh, G., & von Hippel, E. (2006). The promise of research on open source software. Management Science, 52(7), 975–983.

ClimateFlex (19,500 users) show a high level of adoption. The intermediary solutions, which are hybrid tools, such as HydroMap, have moderate and steady levels of usage (15,400 users), indicating that they serve as a tool of mediation between accessibility and the controlled licensing.

The line graph indicates that the open-source tools have had a steady high engagement among the users within various platforms, whereas the proprietary tools have had higher fluctuations because of their licensing fees and restrictions of usage. The trends of hybrid tools are more stable, which is due to their balanced governance structure. Comprehensively, the findings show that the openness of the license to software adoption does not only affect it but also functionality, institutional trust, and user needs, that is, the coexistence of various software governance frameworks in environmental research.

5. Discussion

The results indicate that there is a distinct disparity in stakeholder concerns regarding the environmental software ecosystem. The central role of transparency, data sharing, and reproducibility in scientific research makes environmental scientists very fond of open data. Software developers, in turn, attach more importance to intellectual property protection, emphasizing the issues of incentives to innovations, commercialization, and the sustainability of software in the long run. However, regardless of the increasing support of open-source solutions, the data on its uses show that proprietary tools still enjoy significant user communities, especially when it comes to highly complex features, institutional backing, and track records. This implies that licensing openness is not the only factor that affects adoption decisions, which is also shaped by such factors as performance, reliability, and suitability with the existing research infrastructures. Taken together, these findings stress the intricacy of the process of striking the right balance between openness and proprietary interests in environmental software governance.

6. Suggestions

1. Embrace Hybrid licensing Models: Environmental software developers ought to embrace hybrid licensing models with the capacity to enable partial open source access to the basic applications and the advanced features to be secured under IP protections.
2. Encourage Data-Sharing Standards: Data-sharing protocols should be advocated by research institutions and journals in order to enhance interoperability and reproducibility among software platforms.
3. Encourage Open-Source Code: Funding agencies can also have incentives on the developers contributing to or maintaining open-source environmental software tools.
4. Improve User Awareness: The researchers and developers should be provided with training programs aimed at informing them of the legal and ethical issues of data accessibility and intellectual property rights.
5. Support Public-Private Cooperation: Academic institutions and software companies can collaborate to balance incentives to encourage innovations with increased data access objectives.

7. Recommendations

1. Establish Mixed Governance Structures: Regulators must come up with regulatory structures that combine open data principles and the right IP protection systems.
2. Require Visibility in Publicly Funded Tools: Environmental software that is created through the use of public funds should have some minimum open-access data and methodology requirements.
3. Support Sustainable Open-Source Ecosystems: Institutional support should be given on the long-term basis to maintain, secure and scale up the open-source environmental software.

8. Conclusion

This paper has discussed the tricky nature of the connections between protection of intellectual property and access to data in the environmental software tools environment. The results in a clear manner show that there are opposing views among the major stakeholders. Open data access is highly preferred among environmental researchers as transparency, reproducibility and generation of knowledge through collaboration should be valued in order to solve serious environmental issues. Conversely, software developers are more worried about protection of intellectual property because they believe that this is critical in maintaining innovation, commercial viability, and long-term sustainability of software platforms.

Software usage trends analysis also indicates that, even with the growing interest in the need to use open-source solutions, proprietary tools still have a significant amount of users. This implies that licensing openness is not the sole determinant of adoption decisions, but practical factors like advanced functionality, institutional trust and technical support also influence these decisions. Software models with hybrid characteristics come out as possible compromises, providing accessibility and proprietary protection that is controlled.

In general, the paper emphasizes that the possible clash between openness and IP protection does not necessarily have to be irreparable. The expectancy of the stakeholders may be addressed with adaptive licensing policies, transparent governance frameworks, and enabling policy frameworks to ensure that incentives to innovation are not compromised. Legal structures can be aligned to the normative objectives of environmental research by policymakers and institutions to attract a more inclusive, efficient, and sustainable software ecosystem. The findings of this paper are relevant to the current arguments on open science and technology governance, and provide a contribution to the discussion, which can be utilized in future policy formulation and research activities within the field of environmental informatics.

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