

Article

Legal Risk in the Management of Forest Cover in a River Basin San Juan, Cuba

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Abstract: The protection of forest cover in Cuba is a state priority. It is part of the state plan to deal with climate change. The purpose of this paper is to assess the legal risks associated with the protection of forest cover, which is essential to ensure the sustainability of hydrological watershed management in Cuba. The qualitative method of social research was followed. Techniques of content analysis, semi-structured interviews, and legal exegetics were applied. Geographic information system (GIS) and remote sensing techniques were also used to triangulate data and results. This article provided a robust analytical framework for generating innovative laws for land planning through a three-phase methodological design associated with configuring, interpreting, and applying tools for stopping deforestation processes based on watershed management. As a result, it was demonstrated that limitations reveal a deficient legal application with risk in the river basin, and a significant causal relationship between institutions and communities. Furthermore, the study indicated that although there are legal norms that regulate the protection of forest cover in the studied basin, its vulnerabilities generate uncertainty about the foreseeable results in management of forest cover. It is recommended that the Provincial Council of Hydrographic Basins include the design of legal risk indicators for forest cover management into the sub-plan for forest area increase. These recommendations constitute a set of related actions to improve the sustainability of the above-mentioned management.

Keywords: legal management; deforestation; geographic information system; remote sensing

1. Introduction

Deforestation is one of the seven major environmental problems and has become an important component of sustainable forest management [1]. This phenomenon has led to major changes in the structure and function of river basins [2]. As an anthropogenic process, deforestation leads to the loss of biodiversity, reduces water retention and filtration capabilities, increases carbon emissions, expedites climate change, and has negative impacts on human well-being. For instance, forest depletion is an important factor in climate change,

as it is responsible for direct CO₂ emissions from land use and land-use change, accounting for 12% of all emissions [3,4].

The importance of deforestation and watershed forest depletion must not be overlooked. Forests play a crucial role in maintaining water stability by participating in various components of the water cycle. It is recommended that the Provincial Council of Hydrographic Basins include the design of legal risk indicators for forest cover management into the sub-plan for forest area increase [1,4]. These recommendations constitute a set of related actions to improve the sustainability of the above-mentioned management. They also influence flow regulation processes [5]. Several authors agree that the regulation of water yield in a watershed depends on the type, characteristics, and quantity of vegetation cover present [4–6].

Added to the above are parameters that are responsible for global changes [7–12]; which significantly affect the vegetation cover of watersheds and disrupt their environmental sustainability; such as changes in climatic conditions [13], changes in the ecosystem, and biodiversity [14], changes in the landscape and its fragmentation [15–18], as well as the impact of urban growth [16,19,20].

In this context, how the state expresses efforts to protect vegetation cover through legal norms becomes relevant [21,22]. Also relevant is how it granted the hierarchy of standards, and the issuer of these legal norms gives them a binding force to influence the treatment of deforestation.

In Cuba, sustainable forest management is legally expressed through Law No. 85 of 21 July 1998, which focuses primarily on forest cover, and omits the ontology of a healthy forest ecosystem. In addition to this legislation, a series of resolutions have been implemented by governmental institutions to complement and reinforce the legal protection of forest cover, following the dynamics set forth by the aforementioned law. In Cuba, the protection of vegetation cover has, as a central axis of its legal protection, Law No. 85/1998. As part of the complementarity to this legislation, a set of governmental institutional resolutions guarantee this protection. According to forest dynamics, 31.15% of the national land surface is covered, which makes up the forest patrimony [23]. Different landholders administer this; the most representative are the agroforestry companies, the national flora and fauna companies, and the agricultural and livestock companies.

As part of the country's environmental policy, a State Plan was designed to face climate change (Task Vida) [24], which aims to care for and conserve forest cover. Task number five of this plan develops strategic, institutional, legal, or organizational measures, investments, and other expenditures to guide reforestation towards maximum soil and water protection in quantity and quality. All of this is in congruence with the National Environmental Strategy (2021–2025) where it is expressly stated that deforestation is an environmental problem in the country [25].

The Cuban archipelago has recognized 642 surface basins larger than 5 km² [26]. These basins occupy an area of 8 1143 km², with a variation of the fluvial network from 0.20 to 4.0 km/km². Of these, 11 are watersheds of national interest and 51 of provincial interest [24]. This classification of national and provincial interests is due to the economic, social, and environmental importance of their integrated management at these levels, applying the principles and instruments of sustainable development for their use, integral and rational exploitation to meet the demands of the economy and society, as well as the conservation and protection of the environment [27].

The San Juan River is among the watersheds of provincial interest in Cuba [27]. This watershed contains a rich forest cover. There is currently a growing interest in understanding the legal dimensions that hinder the protection of the forest cover of this watershed, and others in the country that present the same situation. Limitations in management increase the legal risk [21,22,28–44].

Scientific studies define the effects of deforestation on watersheds and its impact on their sustainability [13–20]. Although it is important to consider the legal aspects and associated risks of protecting forest ecosystems, only a limited number of studies

have attempted to incorporate these factors into the watershed management process. Although it is important to consider the legal aspects and associated risks of protecting forest ecosystems, only a limited number of studies have attempted to incorporate these factors into the watershed management process [18–20].

This research defines legal risk as the probability of affecting watershed planning and management processes due to non-compliance or lack of compliance with current legislation. It is associated with the impossibility of demanding compliance with legal norms, generating adverse effects on watershed management processes, as well as the risk of regulatory change by the competent governmental authorities at the local, national, or international scales of enforcement, in a way that adversely affects this management [28].

The legal risk grows with uncertainty about applicable laws and legal regulations. Therefore, it includes legal enforceability [45–48], the legality of management instruments [49], exposure to unanticipated changes in laws and legal regulations [50], the existence of an obsolete legal and regulatory framework, inflexibility and the presence of gaps, antinomies, and ambiguous legal concepts [51–60].

The inefficient use of normative referrals [61–63], and the existence of forwarding chains [64], which generally cause linguistic or communicative, legal-formal, pragmatic, teleological, and ethical prejudice [54], affect the medium- and long-term ecological, economic, and social sustainability of the watershed.

The main purpose of this article is to analyze the legal risks associated with the protection of forest areas, in order to promote the sustainable management of Cuban hydrological basins. The research was driven by a fundamental question: how can legal risks associated with laws and regulations related to forest protection ensure their appropriate integration into forest resource management, using the case study of the San Juan River Basin?

2. Materials and Methods

2.1. Study Area

San Juan River Basin is located in Santiago de Cuba (19°58.0' N; 75°49.4' W), at the east of the Cuban archipelago (Figure 1). The study area has 138.3 km² of superficies, with an approximate average superficial hyper-annual flow of 30.1 hm³ and 12.4 hm³ of groundwater.

It is bordered to the north by the heights of Boniato, to the south by the coastal plateaus and the Caribbean Sea, to the east by the heights of Ochoa and Las Guasimas, and to the west by the heights of Puerto Pelado and the city of Santiago de Cuba, flowing into the area known as Aguadores. Four mixed political-administrative districts (urban and rural) affect the basin. It is made up of a shallow basin and a subway basin, with the latter classified as a free, unconsolidated aquifer. Its forest cover index for 2016 was 33.34% [26,28,30] as an ecosystem under the protection of provincial interest [26,27]. The river basin has 23 settlements and a population of 170,000 inhabitants, about 40% of which is urban [23]. The main tributary flows into the Aguadores Pass in the Caribbean Sea, and its main tributaries are the rivers Seco, Zacatecas, Maisí, Cocal, and Soledad. It is made up of superficial and underground basins [30]. (See Figure 2).

According to the Provincial Council of Hydrographic Basins, the study area has the following environmental problems: (1) Drought. (2) Contamination of the water due to lack of sewerage. (3) Contamination of surface water from the presence of industrial, service, and residential activities; oil spills, and generation of dangerous waste (pneumatic, and bacterial, among others). (4) Degradation of the land. (5) Inadequate use of areas for cultivation. (6) The proliferation of vectors through the flawed system of final disposal of residuals. (7) Contamination of the river essentially by a significant anthropogenic development. (8) Salinization of water through saline intrusion in the dry season. The eight problems mentioned derive from the necessity to conduct relevant research into Cuban river basins [26–28].

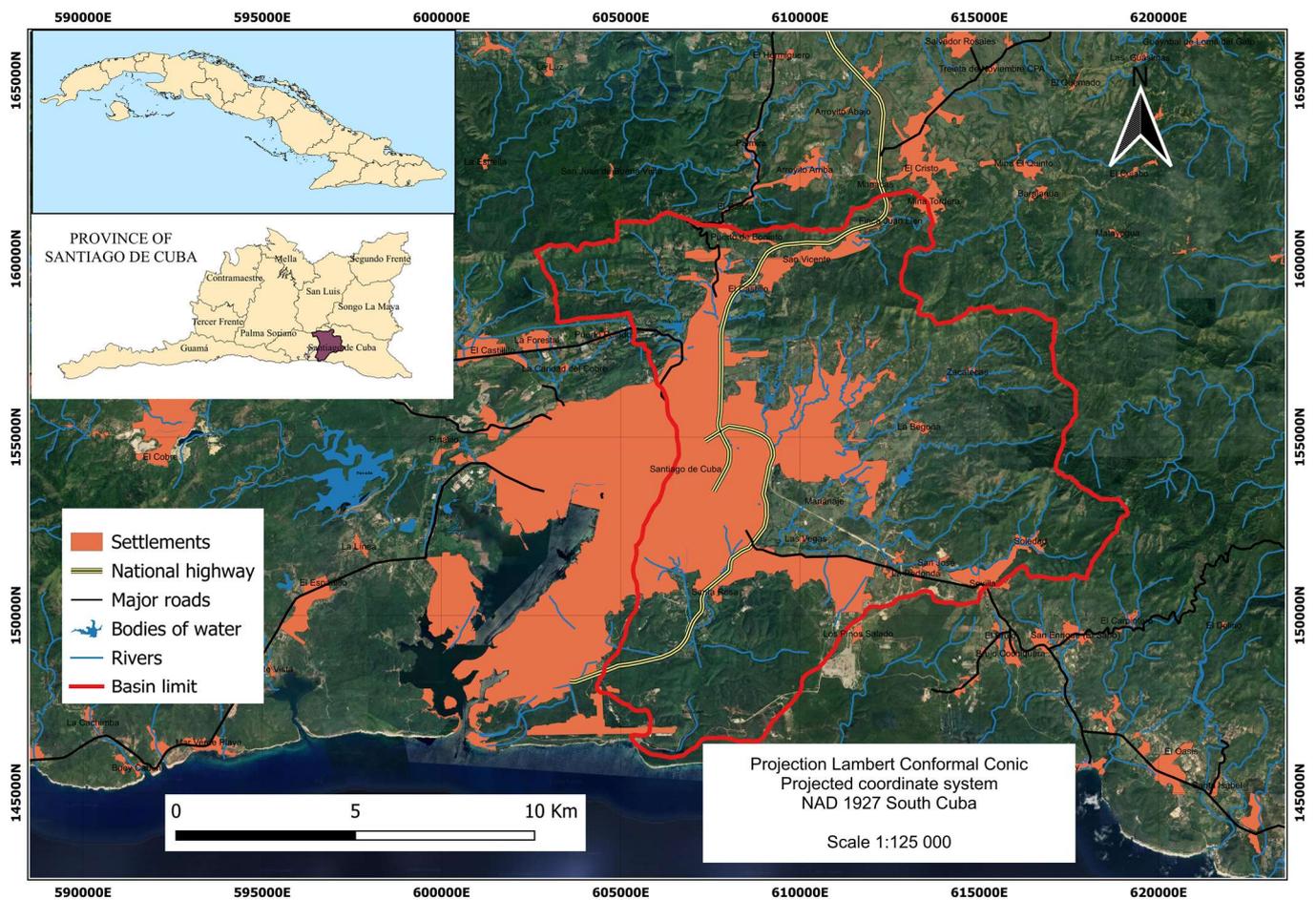


Figure 1. Location of the studied San Juan River Basin. Caption: orange represents different kinds of urban and rural settlement.

2.2. Methods

This research is exploratory and is based on the principles of integrated watershed and coastal zone management [65]. The qualitative methods of social analysis, remote sensing, and geographic information systems were used. The techniques used in the three phases of the work are graphed and detailed below (see Figure 2).

2.3. Phase I. Study of Legal Norms Regarding Forest Cover in River Basins and Their Application in Cuba

2.3.1. Analysis of Documents

Qualitative analysis of documents [66,67] has been used to analyze technical reports [68] verified in the Provincial Delegation of Hydraulic Resources of Santiago de Cuba, and the Provincial Council of Hydrographic Basins of Santiago de Cuba. This review process involved three sets of tasks: (1) Compiling policies related to integrated management in the Provincial River Basin Council from 2014 to 2020, to ensure a census of its dynamics related to deforestation; (2) Identification of the spectrum of policy objectives through qualitative induction as conventional content analysis, text reading, etc.; (3) Description of the attributes and trends of integrated management policies regarding the object of study.

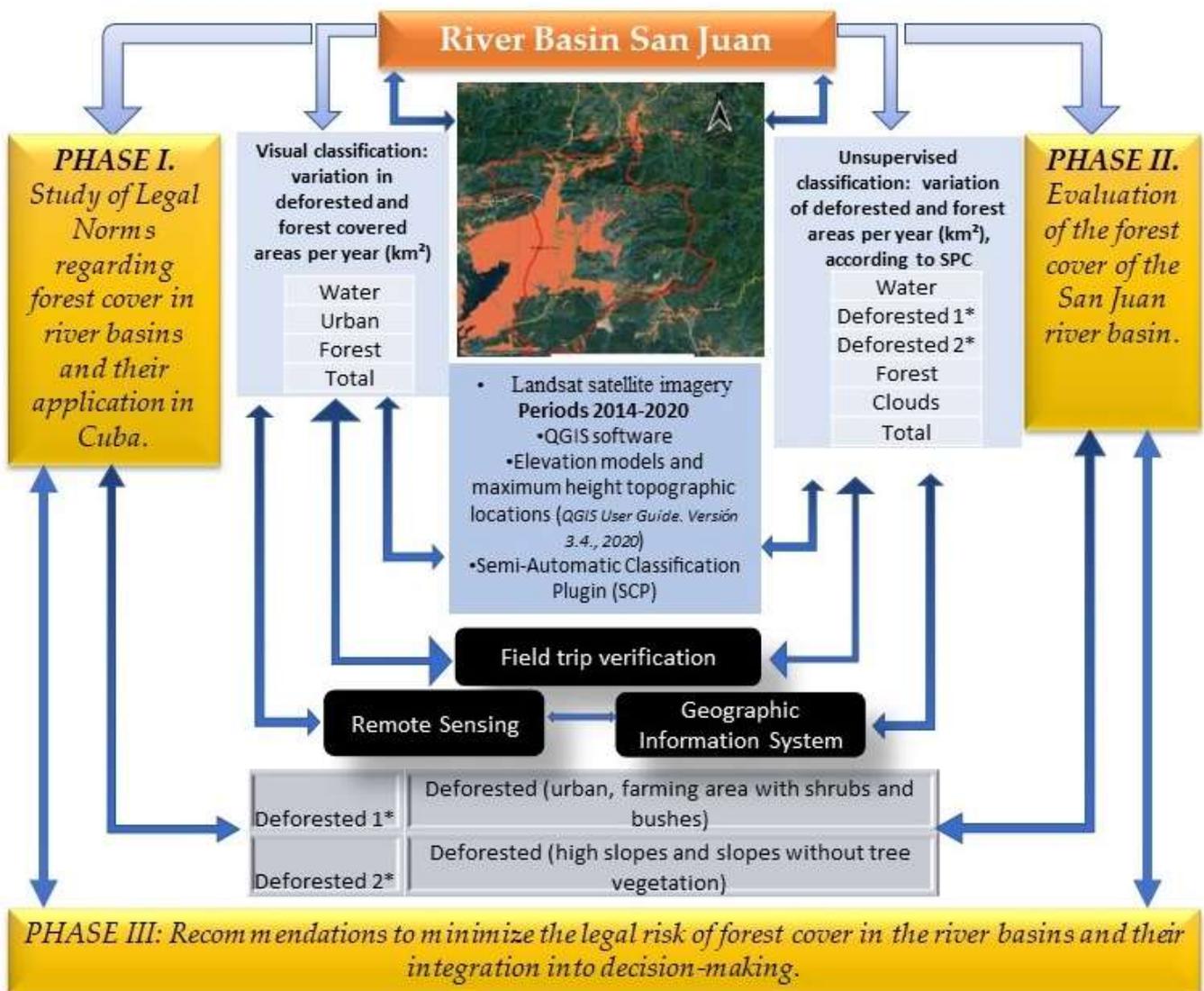


Figure 2. Methodological framework of this research.

2.3.2. Legal Exegetical Method

This method was used to diagnose the technical-legal quality of current deforestation-related legislation, both from a formal and substantive point of view. The diagnosis focused on designing, reforming, or updating legal norms, identifying gaps, antinomies, vagueness, ambiguities of concepts, normative remissions, and their non-compliance in the Cuban legal system. An illustrative table was made containing all the legislations' consulted objectives of these legal frameworks, sectors, and application scale. Subsequently, technical analysis of the legislation is developed according to Villabella [69] and Sánchez [70].

2.4. Phase II. Evaluation of the Forest Cover of the San Juan River Basin

Multi-date, remote-sensed data supported the methodology applied to assess the river basin area changes. Using satellite images, it was possible to identify, calculate, and monitor the forest cover of the San Juan Basin, and the surfaces affected by erosion and anthropogenic processes.

Images were analyzed, corresponding to the years 2014 to 2020. Other tools used in this study were remote sensing, the GIS, and photo interpretation as an interface for both. The importance of these tools in managing the river basin of reference was revealed. Landsat, 8 Level 1 with OLI/TIRS sensor, was used, with 30 m spatial resolution acquired through the Earth Explorer platform of the Geologic Service of the United States—United

States Geological Survey USGS (<http://earthexplorer.usgs.gov/>; accessed on 25 January 2021; USGS, 2020). The radiometric quantification was 12 bits. (See Table 1). The images were pre-processed, transforming to reflectance values. Likewise, the spatial data set has been geo-referenced in WGS84 (World Geodetic System 1984) Reference System and cartographic projection UTM zone 18 (UTM, 2020).

Table 1. Details of Landsat satellite imagery downloaded.

No	Date of Image	Satellite/Sensor	Reference System
1	23 February 2014		
2	25 January 2015		
3	1 April 2016		
4	15 February 2017	Landsat 8 Level 1 (OLI-TIRS)	WGS84/UTM zone 18N
5	2 February 2018		
6	4 January 2019		
7	27 March 2020		

Twelve detailed field visits were made to the river basin forests investigated in this study to determine actual predominant plant species, their distribution, their conditions, and the typology of anthropogenic activities such as road emplacement, expansion of urbanized areas, disposal of waste materials, and illegal logging, among others, and their effects on the environment.

2.4.1. Visual Analysis

This investigation used the following band combinations for each year analyzed on 5/4/3. Infrared. This combination highlights roads and bodies of water, and has good sensitivity to green vegetation. 7/6/4. False urban color. This type of combination identifies urban areas differently from vegetation and forest.

The methodological scheme for visual classification maps was considered [71,72]. The five stages of this process were: (a) Collection and evaluation of satellite information. (b) Union of bands. (c) Evaluation and selection of satellite information under two criteria: (i) A low percentage of cloud cover for each scene; (ii) Review of image quality in the sector of the study area. (d) Designing the mosaic of satellite images. Generated by QGIS. (e) Geometric correction through geo-referencing.

2.4.2. Principal Component Analysis (PCA)

This was used to reduce the number of variables introduced into the geo-information without losing a significant part of it [72], which allows a smaller dimensionality and projection of the “without forest cover” type areas, thus allowing a more accurate visual analysis, for each of the years analyzed [73]. In this research, its use is justified as an enhancement before the visual interpretation that was carried out.

2.4.3. Semi-Automatic Classification Plugin (SCP)

Under raster processing, an automatic workflow occurs. Under synchronized level of component analysis, the Semi-Automatic Classification Plugin (SCP), the data shown in the results are obtained, containing deforested and forest areas in km² [74].

2.5. Phase III. Recommendations to Minimize the Legal Risk of Forest Cover in the River Basins and Their Integration into Decision Making

Semi-structured interviews [75] were conducted with 11 members of the Provincial Watershed Council of Santiago de Cuba, seven members of the State Forestry Service of that province, three members of the Provincial Delegation of Water Resources, two members of the Provincial Delegation of CITMA, eight researchers from the Center for Multidisciplinary Studies of Coastal Areas of the University of Oriente, and three judges of the Economic Chamber of the Provincial Court of Santiago de Cuba with competence until

2020 in environmental issues. The interviews were conducted in two working sessions. They aimed first to identify the levels of knowledge on legislation associated with the ecological sphere in Cuba, specifically in forestry, and then to determine the expressions of legal risk for protecting forest cover in the San Juan Basin. The second session focused on gathering their proposals to mitigate the effects of the manifestations of the identified legal risks.

3. Results

3.1. Legal and Institutional Manifestations of the Legal Protection of Forest Cover in Cuba

The forest is a renewable natural resource of the nation which provides economic, environmental, social, and cultural goods and services, susceptible to being used rationally, without detriment to its regulatory and protective qualities of the environment, which is the inheritance of all the people. The content analysis identified 15 binding legal norms, described in Table 2 and Appendix C.

Table 2. Legal norms identified on forest cover in watersheds in Cuba.

Name of the Legal Rule	Approval Date	Type of Legal Standard/Level of Management	Approving State Body or Agency
Joint Resolution (unnumbered)	23 February 1996	Resolution/National	The Ministry of Agriculture. National Institute of Water Resources
Law No. 81 of the Environment	11 July 1997	Law/National	National Assembly of the People's Power.
Law No. 85 Forestry	21 July 1998	Law/National	National Assembly of the People's Power.
Resolution No. 330. Regulation of the Forestry Law	7 September 1999	Resolution/National	Regulation Ministry of Agriculture.
Decree-Law No. 268. Contraventions of forestry regulations.	8 September 1999.	Decree of the Council of Ministers/National	Decree-Law No. 268. Contraventions of forestry regulations.
Decree-Law No. 200. Contraventions in environmental matters	22 December 1999	Decree-Law/National	The Ministry of Science, Technology, and Environment.
Decree-Law No. 201. On the National System of Protected Areas.	23 December 1999.	Decree-Law/National	System of Protected Areas.
Decree-Law No. 190. On biosecurity.	28 January 1999.	Decree-Law/National	The Ministry of Science, Technology, and Environment.
Decree-Law No. 212. Coastal Zone Management.	8 August 2000.	Decree-Law/National	The Ministry of Science, Technology, and Environment.
Resolution No. 52. Of the National Council, the Territorial Councils, and the specific watershed councils.	7 August 2007.	Regulations/National/Provincial and Territorial	National Council, the Territorial Councils, and the specific watershed councils.
Law No. 113. On the Tax System	23 July 2012	Law/National	The National Assembly of the People's Power.
Decree No. 327. On the Investment Process.	11 October 2014.	Regulation/National	The Ministry of Economy and Planning
Law No. 124.	14 July 2017.	Law/National	National Assembly of People's Power.
Decree No. 337. Regulation of Law No. 124 on terrestrial waters.	5 September 2017.	Regulation/National	Council of Ministers
Cuban Standard NC: 93-01-206 Forest strips of protection zones for reservoirs and riverbeds.	26 April 1996	Technical standard/National	National Institute of Hydraulic Resources.

Source: Modified from the Official Gazette of the Republic of Cuba (www.gacetaoficial.cu); accessed on 20 January 2021.

It has been observed that the legal protection of forest cover has been strengthened through the legal framework, which currently includes 15 applicable rules in the country. These regulations include four laws, four decrees-law, three decrees, three resolutions, and

one technical standard. Of the 15 laws, 9 were enacted in the 1990s and the remaining 6 in the 21st century.

As shown in Appendix A, the profuse legislation guarantees the right enshrined in Article 75 of the Constitution. This recognizes the right of all people to enjoy a healthy and balanced environment, being the state responsible for protecting the environment and natural resources. It recognizes the close linkage of the state with the sustainable development of the economy and society, to make human life more rational and ensure the survival, welfare, and security of present and future generations [76].

Under the guidelines of the forestry framework legislation, the protection, growth, and sustainable development of the nation's forest heritage are promoted. At the same time, reforestation for economic, protective, or social purposes is encouraged, and its efforts are to conserve the biological diversity of resources associated with forest ecosystems.

Integrating this legislation with watershed management strengthened the water system through legal protection as the driving force of the watershed. Land use planning is the main instrument of the permanent planning process for the sustainable use of its natural resources. The legal framework described above lays the foundations for actions aimed at conserving, protecting, or preventing deterioration.

At the institutional level, the National Watershed Council is responsible for coordinating, controlling, and promoting the implementation of integrated watershed management. They have a work subprogram aimed at increasing the forest area. The Ministry of Agriculture is directly responsible for this. This is the agency in charge of directing, executing, protecting, and overseeing forest resource increase and sustainable development.

This Council is composed of a president, a vice president, a secretary, and permanent members for the fulfillment of its functions. The president of the National Institute of Hydraulic Resources presides over it. To satisfy the legislation in its area of competence, it is in charge of, among other functions, controlling the increase in forested area in the hydrographic basins. Another function is to recommend, coordinate, and evaluate integrated management programs to be implemented in the basins, which combine the sustainable use of natural resources with economic and social activities.

3.2. Legal Aspects That Reveal Legal Risk in the River Basin Management Legal System

The review of the legal framework for the protection of forest cover and the surveys identified the following aspects of the legislation that could pose a legal risk to the legal order of the watershed:

- A. Regarding legal enforceability, the principal cause of their existence is non-compliance with the provisions, technical regulations, and recommendations of the State Forest Service. This has led to the filing of infringement proceedings, mainly related to infringements of the conditions on:
 1. Forests and forest management: conduct such as authorizing and carrying out silvicultural management other than the law was observed. Other actions such as not preparing and submitting for approval forest management projects. Failure to comply with the forestation and reforestation program in the mandatory areas established by law. Also observed were behaviors associated with the construction of housing and facilities, the promotion of crops, and the carrying out of earthworks not permitted in forest strips. As well as not complying with the technical regulations of the State Forest Service; carrying out clearing work without the express authorization established in the law.
 2. The Forestry Registry: failure to comply with the provisions issued by the Forestry Registry.
 3. Protection and conservation: non-compliance with phytosanitary technical norms to prevent and combat tree pests and diseases; failure to carry out sanitary felling of burned, plagued, or diseased trees; grazing of large or small livestock belonging to them, or in their custody, without the corresponding authorization from the State Forest Service; and failure to request an initial evaluation by

the Ministry of Agriculture to obtain permission or approval for any work or investment that could affect the forest patrimony.

4. Fire prevention and extinguishing: failure to comply with preventive fire control and extinguishing measures and rehabilitation of affected areas; and failure to prepare or keep the forest fire protection plan up to date.

The primary measure applied is an administrative fine.

It is essential to point out that, even though the law itself—Decree No. 268 of 8 September 1999—leaves open the possibility of claiming civil liability for damages caused to the forest patrimony by the infringing conduct, it is not used, and there is an absence of proceedings of this nature in the competent courts. They made no use of it, and there is an absence of processes of this nature in the competent courts.

- B. The legality of management instruments: the forest framework legislation (Law No. 85 of 21 July 1998) certainly establishes forest management instruments, namely: forest management; afforestation and reforestation; forest harvesting and industry; contracts and other legal acts on forest patrimony; and forest conservation and protection. However, the main legal violations are related to silvicultural management other than those established in the law and its regulations. In addition to implementing management instruments without complying with all the requirements specified in the legislation, the cause of the infringement was conducted.
- C. Exposure to unanticipated changes in laws and legal regulations: some authors are currently working on strategic topics that will allow us to move towards sustainable forestry development. These are the achievements of forest management, the fulfillment of the 'life task' and, within it, the reforestation program of the watersheds. First, more significant legislative development is necessary to establish mechanisms allowing updated and quality forestry information based on scientific criteria and methodologies. A greater legal profusion of incentives for protection and reforestation is required, indispensable for managing existing natural forests, restoring and rehabilitating degraded areas, and establishing forest plantations. It is a challenge to strengthen further forest certification as a legal instrument for environmental management, and a guarantor of the principle of sustainability. Finally, to further develop the legal evaluation of ecological effects on the forest's heritage.
- D. Existence of a legal regulatory framework that is outdated, inflexible, and with gaps, antinomies, and ambiguous legal concepts:

All the legislation that is identified as part of the protection of the forest cover in the watersheds must be updated according to the foundations of the Constitution of the Republic of Cuba, approved on 10 April 2019; and the legislative schedule that has been approved and is being fulfilled rapidly; which has brought as a consequence the improvement of our model of society and state, which undoubtedly influences the legal dynamics of the entire Cuban legal system in force. It is illustrated with two examples:

1. The contraventions legislation—Decree No. 268 of 8 September 1999, and Decree-Law No. 200 of 22 December 1999—do not contain the modifications that the Cuban monetary system, which was updated in the year 2020, has undergone.
2. Legislation: Law No. 81 of 11 July 1997. Environmental Law; Law No. 85 of 21 July 1998. Forestry Law: has not updated the structural system of the state, which, since the Constitution itself is its organic part, has made substantial modifications to that system. In addition, the Magna Carta is notably lacking in developing a plan of guarantees of rights that must be designed according to the specificities of both framework legislations, fundamentally concerning the right to enjoy a healthy and balanced environment.

Likewise, the following cases of ambiguity have been identified in the legal framework referring to the object of study:

1. Excessive use of the gerund. Examples: prevailing, fulfilling, having, pursuing, respecting. In all cases, the use of the gerund has an illative value. In other words, the

- gerund does not express a circumstance that marks the action of the main verb, but is used to link autonomous events.
2. Cumulative tendency to use adverbs. Examples: generally, fundamentally, permanently, only, jointly, legally, independently, totally, duly, economically, orderly, biologically, socially, systematically, integrally, properly, scientifically, previously, equally, personally, significantly, am-environmentally, exceptionally, gratuitously, continuously, partially, accidentally, potentially, indirectly, sensibly, rationally, currently.
 3. There is a set of terms in the legislation with extensive vagueness. Their indeterminacy affects the scope of application of the concept: official character, effective operation, positive results, prudent time frame, periodic meetings, usual ebb and flow of the tides, justified reasons, sustained increase in the values of the forest resource, irrational logging, environmentally sound criteria.
- E. Use of normative referrals. Its main manifestations are: Forestry Law, technical standards in force, methodology established by the Forestry Directorate, Cuban standards, foreign investment law, forestry management projects or management plans, and methods based on the Forest Ranger Corps. These normative referrals are external, dynamic, and in a block (Table 3).

Table 3. Classification of legal risk manifestations and associated behaviors from the interviews.

Manifestation of Legal Risk	Conduct Associated with the Manifestation	Principal Impact
The legal enforceability	Failure to comply with the provisions issued by the Forestry Registry. Failure to comply with phytosanitary technical standards. They are failing to submit for approval forest management projects. The areas have a forestation and reforestation program. Failure to comply with preventive fire control and extinguishing measures.	Illegalities
The legality of management instruments	The constant use of silvicultural management methods differs from those established in the legislation.	Illegalities
Exposure to unanticipated changes in laws and legal regulations	It does not provide practices associated with sustainable forestry development for forestry legislation.	Illegalities
Existence of a legal, regulatory framework that is outdated, inflexible, and with gaps, antinomies, and ambiguous legal concepts.	Existence of vague legal concepts and ambiguous and imprecise terms. Legal norms that are not adapted to the current reality.	It is associated with legality requirements in legal norms.
Use of standard referrals	Referral to various legal provisions or methodological documents of the State Forest Service, which have levels of legal outdatedness.	It is associated with legality requirements in legal norms.

The analysis of documents revealed the dynamics of management policies related to deforestation in the basin of reference in the period studied (Table 4).

Finally, the analysis of documents also revealed the following significant violations of forestry regulations in the watershed under study. These are silvicultural management other than those established by law and failure to comply with the provisions, technical rules, and recommendations of the State Forestry Service. Again, legal entities predominantly committed these behaviors.

Table 4. Dynamics of management policies related to deforestation in the San Juan River Basin.

Types of policies designed and implemented by the Provincial Council of Hydrographic Basins	Administrative policies	36
	Technical policies	56
	Educational policies	8
	Environmental policies	12
	Community Outreach policies	8
	Institutional policies	28
	Total	148
Main goals	<ul style="list-style-type: none"> Comply with the afforestation indexes of the basin under an integrated management approach. 	
Main trends observed	<ol style="list-style-type: none"> Existence of an institutional desire to preserve the basin. Carry out concrete actions (investments, information, and training) to preserve the forest cover. Search for international agreements and financing contributing to preserving the basin’s forest cover. Achieve more excellent territorial governance, community participation, training, and involvement. The forest volume estimation method for forest cover calculation is insufficient due to its marked subjective nature. 	

3.3. The Causal Relationship between the Legal Limitations and the Damages Embodies the Legal Risk

In relation to legal risks and their effects, it is necessary to highlight the consequences that they have expressed in damage to the legal dynamics, with consequent repercussions in the legal relationship protected in the legislation [54]. See Figure 3 and Table 5.

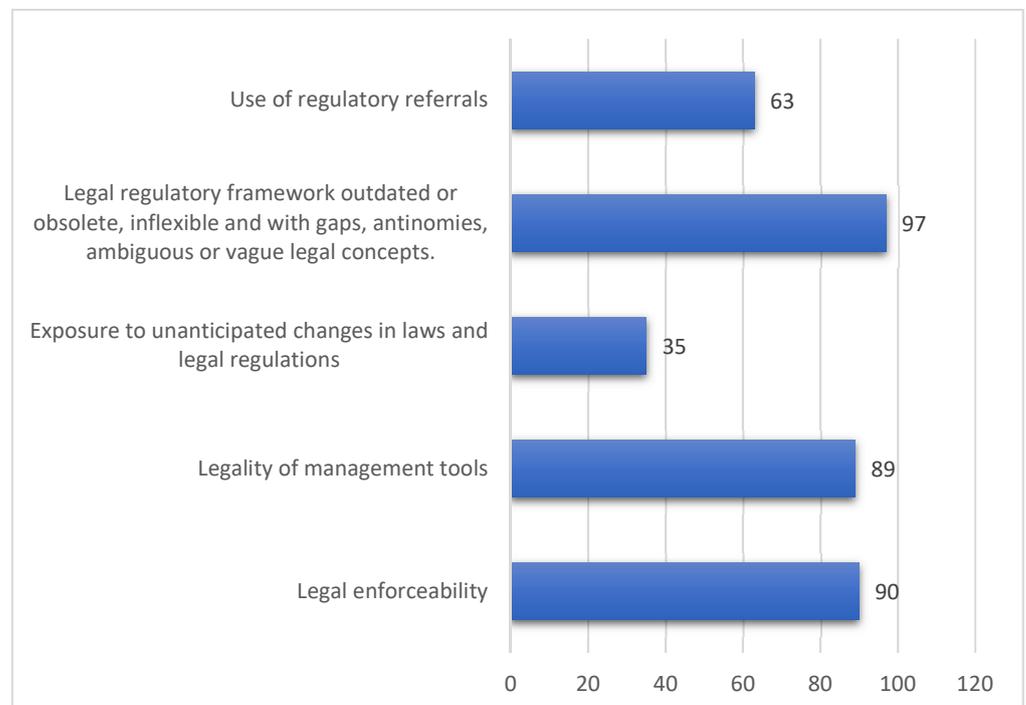


Figure 3. Levels of incidence of demonstrations according to interviewees.

Table 5. Relationships between legal limitations according to damage and effects.

Legal Limitations	Damages	Effects
Legal enforceability	Legal-formal Ethical	Contravention behaviors
The legality of management instruments	Legal-formal Ethical	Contravention behaviors
Exposure to unanticipated changes in laws and legal regulations	Pragmatic Teleological	Contravention behaviors
The legal regulatory framework is outdated, inflexible, and with gaps, antinomies, ambiguous legal concepts	Linguistic or communicative legal-formal	Infringement of the guarantees associated with the formal and material requirements of legality.
Use of regulatory referrals	Legal-formal	Infringement of the guarantees associated with the formal and material requirements of legality.

According to the results of the survey, 97 percent of respondents said that Cuba's legal and regulatory framework related to forest cover is outdated. Law No. 85 of 21 July 1998 is the main legal regulation and does not contain the latest standards for healthy forest ecosystems. Furthermore, there is a lack of legal harmonization with the new Law No. 150 on natural resources and environmental systems. The application of the ecosystem approach as a fundamental strategy for national integrated natural resource management has not been recognized. There is a lack of systematic utilization of modern remote sensing techniques and geographic information systems such as QGIS, ArcGIS, GLOBALMAPPER, MAPINFO, and AUTOCAD forest management [55].

A figure of 90% of respondents indicated non-compliance with the regulations issued by the forest registry, especially with regard to phytosanitary regulations. In addition, 89 of the respondents believe that current forest management practices deviate from legal requirements. This is partly due to outdated forest laws, which do not cover silviculture practices such as conversion of lowland forests to middle forests, selective logging, and extensive and intensive silviculture. In addition, the law does not recognize the processing of forest management-related information through artificial intelligence-based storage mechanisms [56].

As part of the legal loopholes and their main effects, two important consequences have been identified. These are contraventional behaviors, and the violation of guarantees associated with legal requirements. According to the respondents, the main legal infringements are related to:

- Construction of houses, facilities, expansion of crops, and unauthorized change in land use in forest belt;
- Logging in forest areas;
- Failure to comply with afforestation and reforestation programs in areas that are mandated by law;
- Land clearing not expressly authorized by law;
- Grazing livestock, large and small, in forest areas without corresponding permits;
- Non-permanent use of forest land for agroforestry, tourism or recreational purposes without the approval of the State Forest Service;
- Use of fire in and around forested areas without authorization from the Ranger Service, or, even if authorized, without observing established safety measures;
- Failure to implement preventive measures for fire control and fire suppression, and restoration of affected areas as ordered by the competent authorities.

3.4. The Case Study on Deforestation in the San Juan Basin (2014–2020)

The application of the Remote Sensing method and the use of GIS led to the following results. Landsat 8 Level 1 type images of the San Juan River Basin were obtained (Figure 4), along with the delimitation of the study areas in QGIS (QGIS, 2020) (Appendix A).



Figure 4. Landsat type images obtained of San Juan River Basin.

Combining bands 5/4/3 and 7/6/4, the vegetation cover of the urban areas in the basin under study was obtained. The first combination provided the plant biomass. Infrared, red, and green channels were combined. The result yielded a false-color composition, whereby the vegetation is seen in red, and the areas devoid of vegetation are seen in blue and brown.

The increase in deforestation in the basin is present from the central area outwards, around the main axis, which we can call eccentric. This growth pattern occurs in the area corresponding to the urban city, bordering the roads and central infrastructure. Deforestation decreases as we move away from population centers.

Bands 7/6/4 show urban areas. They combine shortwave infrared channels 1 and 2, thus distinguishing and improving the reading of soil moisture and vegetation and the slopes of vegetation. Magenta hues are urban areas. The olive green to bright green ones are the forest areas.

The principal component analysis obtained in Appendix B was decisive for dimensionality and data volume reduction. In addition, this analysis led to minimizing loss of information, and enhanced spectral contrast in the basin under study.

Figure 5 shows the visual classification of deforestation in the river basin by the years analyzed. The resulting images take on exaggerated colors. However, these are not randomly reassigned but retain their initial tonality. This allows the association of each one to the same physical characteristics of the initial area. The vegetative vigor or presence of vegetation in the study area emerges as a new main component.

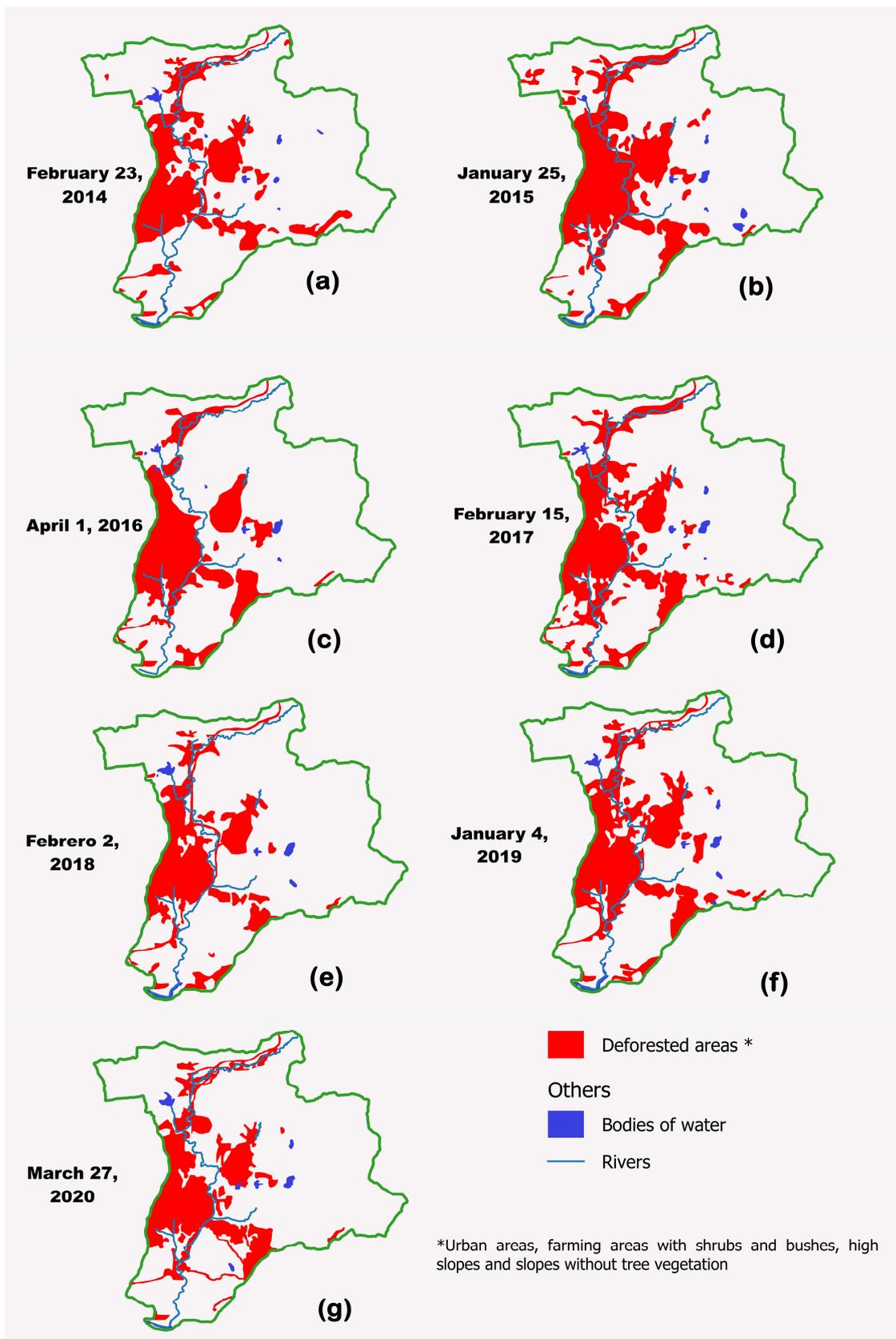


Figure 5. Visual classification of deforestation by years. (a) Year 2014. (b) Year 2015 (c) Year 2016; (d) Year 2017; (e) Year 2018; (f) Year 2019; (g) Year 2020.

The visual classification allowed us to segment the images and interpret them from the organization of the homogeneous spectral data. These maps, and their cartographic precision, show a construction of the mosaic of pictures of the behavior and dynamics of deforestation due to the reduction of radiometric distortion.

The combination of 5/4/3 (infrared) and 7/6/4 (false-urban colors) bands produced a visual classification capable of identifying deforested areas (Tables 6 and 7). For visual classification, three categories were identified: water, urbanization, and forest. The urbanization category was considered an area of deforestation, as it has been observed that activities related to urbanization, such as settlements, roads and crops, are the main cause of this phenomenon. It should be noted that the area of deforestation due to other causes is also included in this category (Table 6). Variations in values can be attributed to variations in the phenomena themselves, as well as specific features of the images used, such as the presence of clouds and shadows.

Table 6. Visual classification: variation in deforested and forest covered areas per year (km²).

	2014		2015		2016		2017		2018		2019		2020	
	km ²	%												
Water	1.10	0.78	1.33	0.94	0.65	0.46	1.10	0.78	1.20	0.85	1.36	0.97	1.18	0.83
Urban	30.54	21.62	37.79	26.75	30.67	21.72	34.67	24.55	26.39	18.68	32.69	23.14	29.05	20.56
Forest	109.61	77.60	102.14	72.31	109.93	77.83	105.48	74.67	113.65	80.46	107.20	75.89	111.03	78.60
Total	141.25	100.00												

Table 7. Indexes of deforested areas observed (km²).

Periods	Initial (km ²)	Final (km ²)	Difference (km ²)
2014–2015	31.64	39.11	7.48
2015–2016	39.11	31.32	−7.79
2016–2017	31.32	35.77	4.45
2017–2018	35.77	27.60	−8.18
2018–2019	27.60	34.05	6.46
2019–2020	34.05	30.22	−3.83

The information presented in Table 7 is derived from the calculation of the area of the vector layer after the annual visual classification. These figures represent the change in the area of deforestation in square kilometers between successive years.

Tables 6 and 7 show that the most severe deforestation periods occurred in 2015–2016 and 2017–2018, resulting in losses of (−)7.79 km² and 8.18 km², respectively. The main factor driving deforestation in both periods was the expansion of human settlements.

It is estimated that during 2015–2016, deforestation affected about 19.8 km², which is about 14.31% of the study area. At the same time, the unsupervised classification allowed us to recognize the spectral classes of the images and their reduction autonomously and interactively, depending on the interpretation of the results obtained. This is evidenced in the same way that the years of most significant deforestation were 2015–2016 and 2017–2018.

The results indicated are consistent with the reports in the national Cuban scientific literature [3,24–26], where it is referenced that in these years, there were evidenced affectations and variations to the forest cover. Exacerbating the previous causes was a decrease in young plantations, and low quality of the plantations that did not achieve adequate technical parameters to establish a plantation by the third year. A figure of 90% of those interviewed highlighted this aspect because it impacts the legal enforceability of forest management in the watershed.

4. Discussion

The current Cuban Constitution recognizes the protection of the environment and the country's natural resources in Article 75 [77]. In this sense, the Cuban state has promulgated legal norms in forest coverage and watershed management. This allows for consolidating the material conditionality of this right. There is complete correspondence with the international trend [76–87] of recognizing the legal protection of this coverage due to its importance to the balance of nature and its ecological, social, and economic multifunctionality, guaranteeing its sustainability.

The primary cause of the observed increase in deforestation within the analyzed watershed is the expansion of urban areas, which is consistent with the reports of the Provincial Council of Watersheds in Santiago de Cuba. These reports indicate that the rapid expansion of human settlements, the majority of which are informal or irregular in nature, is the driving force behind this increase [88].

The main reason for the increase in deforestation observed within the analyzed watershed was the expansion of urban areas, which is consistent with the report of the Provincial Council of Hydrographic Basins of the Province of Santiago de Cuba [30,67]. These reports suggest that the driving force behind this growth is the rapid expansion of human settlements, much of which is informal or irregular.

Illegal logging of wood and non-wood forest products also has an effect, leading to soil erosion in the study area. To a lesser extent, forest fires are associated with land delivery to usufructuaries by Decree-Law No. 259/2008, “on the delivery of idle lands in usufruct,” as well as in the process of organizing agricultural areas. Fire is used to renew idle lands and clear new areas for farming activities.

Similarly, the spaces reserved for discretion, and the overlapping of regulatory powers between the different agencies responsible for law enforcement have an impact. It is generating uncertainties about the foreseeable results in managing forest cover in the watershed that are consistent with the current legislation's application. This aspect is weighted by its influence in Sodik [89], specifically for marine pollution, but 97% have remarked on it in this study.

The findings in this study are consistent with reports in the Cuban scientific literature [90], which describe changes in forest cover over the same period. In addition to the previously identified reasons, the literature highlights the reduction of plantation seedlings and the insufficient establishment of technical parameters for successful plantation establishment after the third year of growth [88].

Studies [91] have focused on the failures of legal regulations in specific coastal scenarios and the political instability of regulatory laws [92–96]. However, the scientific findings of this result show that the causes that generate deficiencies in legal norms are analyzed for the first time from the perspective of legal risk, at least for Cuba.

Authors such as McCormick [97], Whalley [98], and Tsui [99] have suggested an approach to legal risk from the perspective of how much the application of the rule of law affects profitability, applying the analysis to corporate and judicial matters. However, the view proposed in this article reveals that there are dimensions that strengthen the ontology of legal risk and are outlined in the probability of affecting watershed planning and management processes, based on the direct possibility of losses due to non-compliance (or imperfection) of legislation affecting watershed management or the impossibility of enforcing compliance with legal requirements for proper watershed management; or as a risk of regulatory change by the competent (governmental) authorities (local, national or international) of the regulations in a way that adversely affects this management [28].

The scientific path followed in this study indicated the need for a strategic law enforcement policy to significantly reduce deforestation [100–102]. This will allow the identification of the legal vulnerabilities that determine legal risk, and the creation of an analytical framework to generate innovative legal strategies associated with the results, interpretation, and application of laws to curb deforestation processes in watershed management.

Finally, the identification of legal limitations has been an essential component in revealing that their principal effects are concentrated in two aspects that hinder the development of an integrated policy for the protection of forest cover in watersheds. These are the proliferation of contraventional conducts, and the violation of the guarantees associated with the formal and material requirements of legality.

Such effects become weaknesses that complicate, annul, or weaken reforestation policy, generating inconsistencies [91] in implementing solutions from watershed management process [28].

The results obtained in other relevant previous works [91] coincide with some of the aspects analyzed in the present study, namely the shortcomings of the legislative and legal framework in coastal areas, and the application of forestry legislation to comply with the reduction of forestry emissions. However, the proposal revealed critical legal implications. From the point of view of legal innovation, it is a good proposal for making informed decisions on legal risks, such as prioritizing relevant actions to protect forest cover in the watershed management process.

Legal risk assessment is very useful in the decision-making process of watershed management [38–40]. Without identifying legal loopholes, it is not easy to identify issues related to the legal protection of forest cover. Without a systematic form of decision making, binding provisions cannot be developed to mitigate or reduce the impact of deforestation [10,12,14]. The legal risk analysis provides direction to provincial council members of the Hydrological Basin Commissions and allows legal risk information to be incorporated into their government decision making.

In other words, the risk-informed decision-making process of integrated forest cover management affects the sustainability of watershed management.

5. Conclusions and Recommendations

This research integrates the legal dimensions and risks related to protecting vegetation cover in the watershed management process. Using the principles of integrated watershed and coastal zone management, three phases of work were designed to address the legal risks under reference. The results indicate that legal limitations reveal legal trouble in the legal system of the basin, with an important causal relationship between those and the damages that the legal risk embodies. This last result helps informed decisions to be made in the watershed management process. This study is generally novel in its approach, and its results are essential in the Cuban context.

It is of great value in highlighting the significance of identifying the legal constraints for assessing risk in a legal environment for the legal fabric of forest cover.

The proposed approach can incorporate the assessment of different socio-economic conditions affecting the reference ecosystem. Furthermore, due to the interdisciplinary nature of the article, new nodes of scientific research on the role of the institutional-legal subsystem in the hydrological basin management process are revealed. For example, assessing the relationship between legal risk and ecosystem protection; integrating and detecting legal risk in innovative decision making in hydrological watershed management; and legal innovation strategies for the sustainability of watershed management processes.

The framework presented here can also be applied to determining legal risks to ecosystems such as mangroves, estuaries, swamps, and mountain ecosystems.

In view of the fact that the legal risk assessment of forest cover protection in the Cuban watershed requires comprehensive measures and is a dynamic management process, the following recommendations are made to the Provincial Council of Hydrographic Basins:

1. When managing Cuban hydrological watersheds through subprograms, it is recommended to include: increase in forest area; and design of legal risk management indicators for forest cover management.
2. Identify legal risks and their causation.
3. Identify responsible parties and their level of responsibility (civil, administrative setting, and criminal).

4. Design relevant measures to deal with or reduce legal risks.
5. Strengthen the integration of the main bodies of the Provincial Council of Hydrographic Basins, and comprehensively deal with legal risks.

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Appendix A

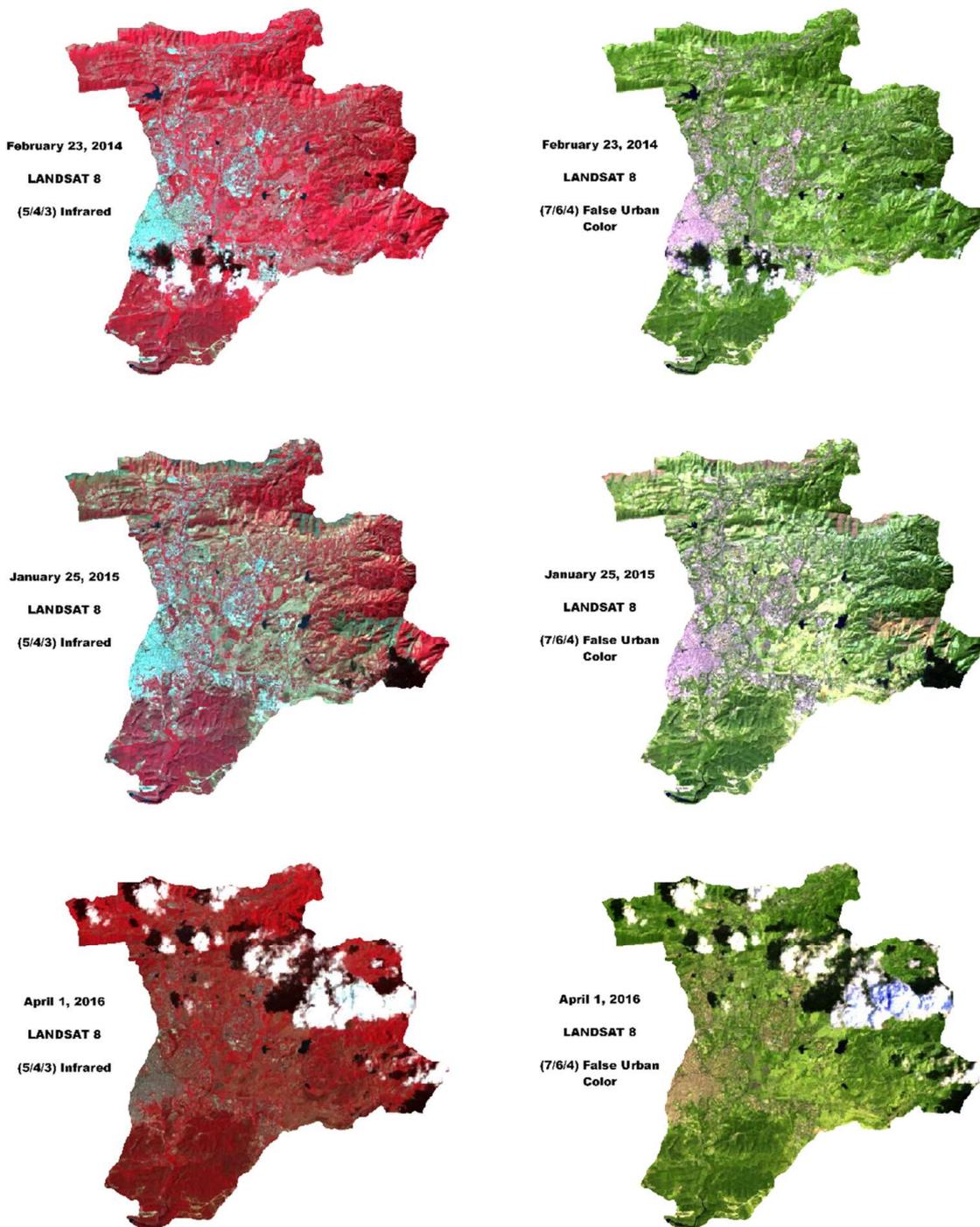


Figure A1. Satellite Band Composition Obtained.

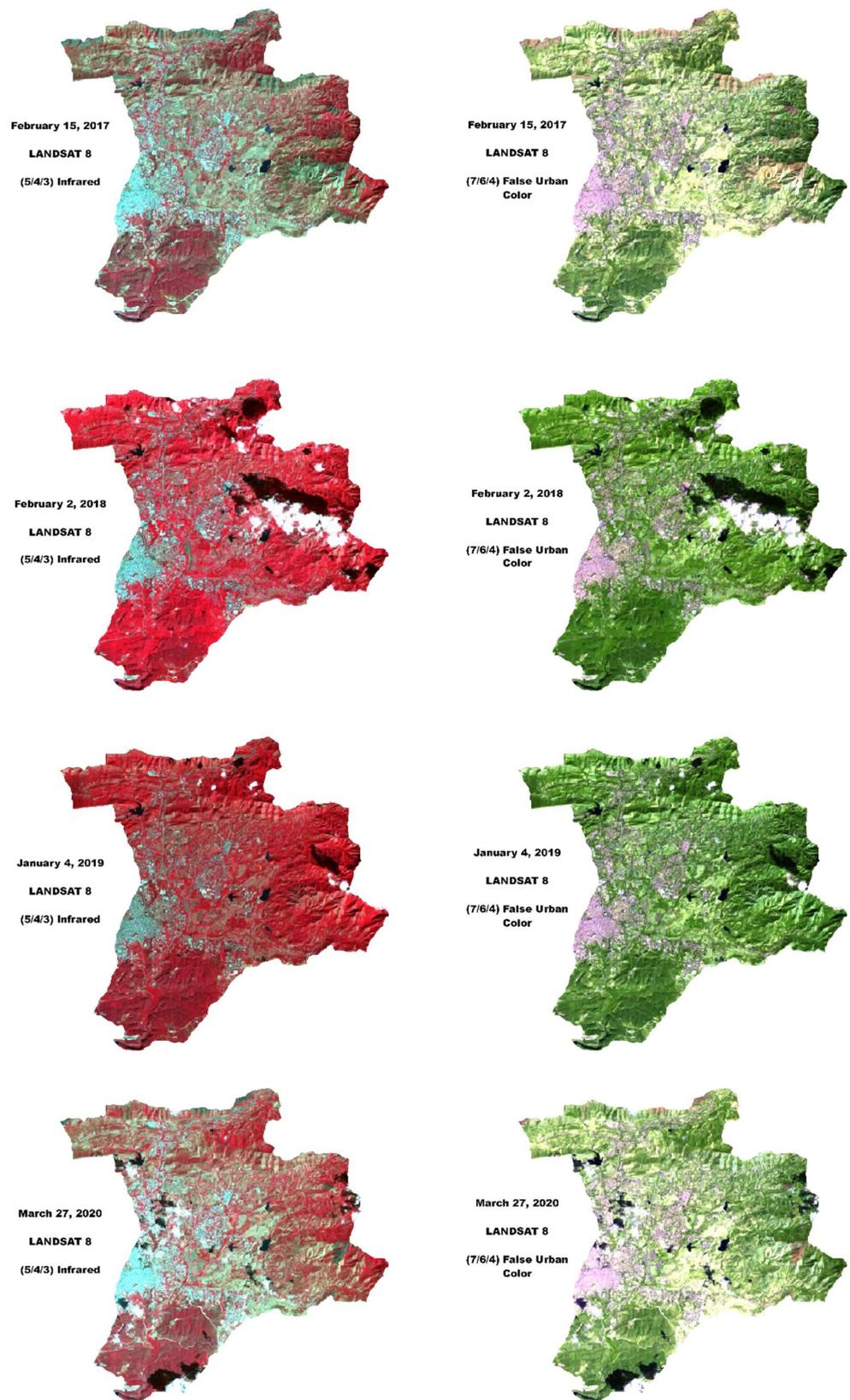


Figure A2. Satellite Band Composition Obtained.

Appendix B

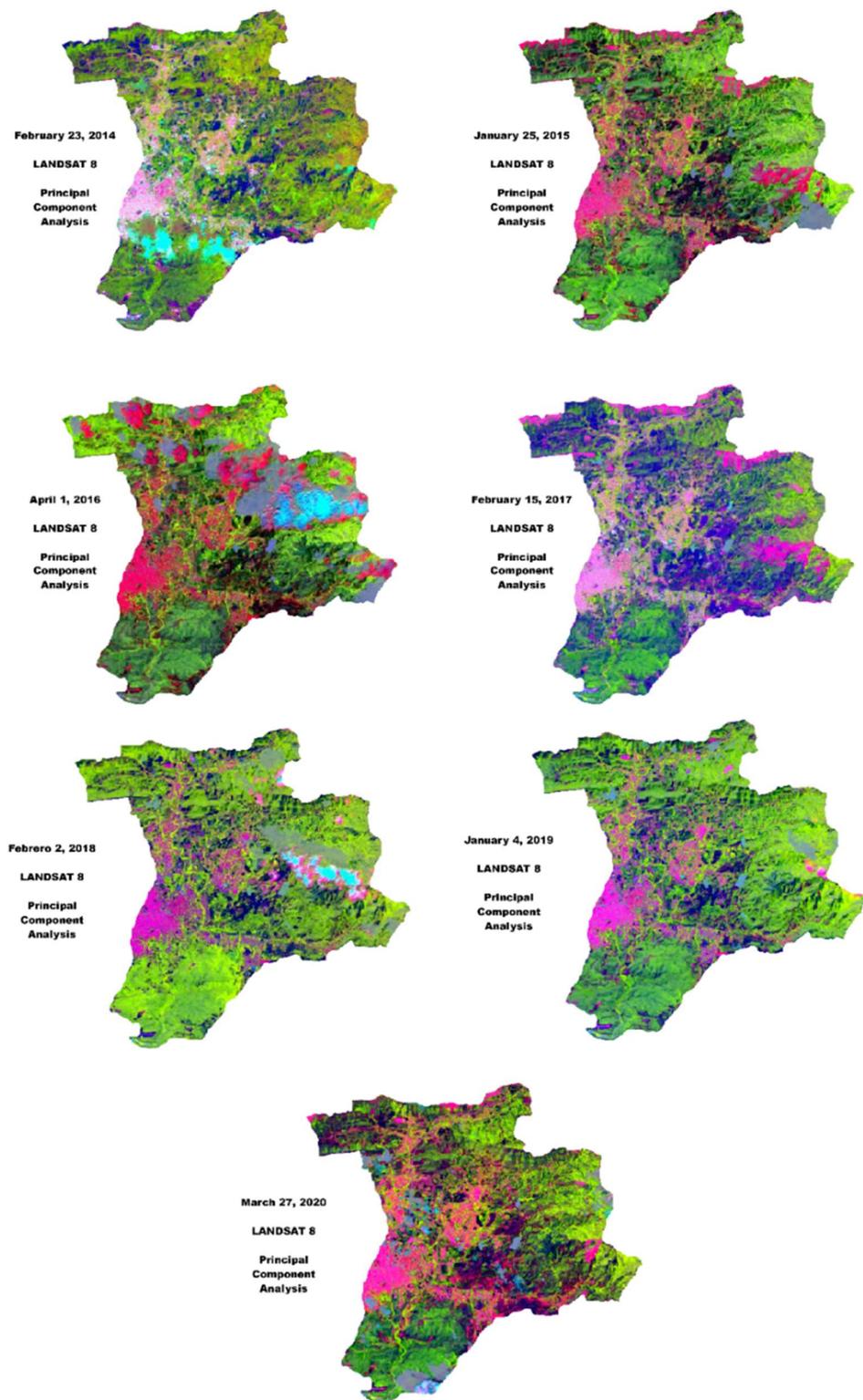


Figure A3. Analysis of the Main Components for the Projection of Areas Type “Without Forest Cover” (Caption: Color Green Represents Vegetation Remains while Coloring Magenta Urban Areas).

Appendix C

Table A1. Detailed Description of the Goals, Sectors, and Scales of Application of the Laws.

Cuban Policies Applied by the National Council of Hydrographic Basins	Goal	Sector of Application	Scale
Law No. 81 of 11 July 1997. Environmental Law. National Assembly of People's Power.	To create a legal context that favors the projection and development of socioeconomic activities in ways that are compatible with environmental protection; to establish the principles that guide the actions of natural and legal persons in environmental matters, including coordination mechanisms between the different bodies and agencies for efficient management; to promote citizen participation in the protection of the environment and sustainable development; to develop citizen awareness of environmental problems, integrating education, dissemination, and environmental information; to regulate the development of environmental evaluation, control, and surveillance activities; to promote the care of human health, the improvement of the quality of life, and the improvement of the environment in general.	Natural and juridical persons, Cuban and foreign, following the provisions of this Law.	National
Law No. 124 of 14 July 2017. Water Law. National Assembly of People's Power.	It regulates the integrated and sustainable management of terrestrial waters found within the earth's crust or above it, regardless of their physical, chemical, or bacteriological composition, in the space that makes up the emerged part of the national territory limited by the coastline.	Natural and juridical persons, Cuban and foreign, following the provisions of this Law.	National
Law No. 85 of 21 July 1998. Forestry Law. National Assembly of People's Power.	Establish the principles and general regulations for the protection, increase, and sustainable development of the nation's forest heritage; control forest heritage resources through established regulations and competent bodies and agencies; promote and encourage reforestation for economic, protective or social purposes, as well as silvicultural management in plantations and natural forests; to conserve the biological diversity resources associated with forest ecosystems; to protect forests against deforestation, irrational logging, forest fires, free grazing, pests and diseases, as well as other actions that may affect them; to regulate the multiple and sustainable use of the forest heritage and to promote the rational use of non-timber forest products.	Natural and juridical persons, Cuban and foreign, following the provisions of this Law.	National
Law No. 113 of 23 July 2012. Tax System Law.	It establishes the taxes, principles, norms, and general procedures on which the Tax System of the Republic of Cuba is based.	Natural and juridical persons, Cuban and foreign, per this law's provisions for each tax.	National

Table A1. *Cont.*

Cuban Policies Applied by the National Council of Hydrographic Basins	Goal	Sector of Application	Scale
Decree Law No. 200 of 22 December 1999. Contraventions in Environmental Matters. Ministry of Science, Technology and Environment.	Establish applicable contraventions in environmental matters.	Natural or juridical person, national or foreign, who violates the environmental legislation in force.	National
Decree No. 337 of 5 September 2017. Regulation of law no. 124 on land waters.	The protection, safety and conservation of the water infrastructure; the execution of the investment process for water infrastructure works; the preparation of technical standards governing land water management; the granting of concessions and authorizations related to land water management; the annual, medium-, and long-term planning of land waters and their control; the provision of public water supply and drinking water, sanitary sewerage and storm sewerage services; and the composition and functions of river basin councils.	Water Resources Institute.	National
Resolution No. 330 of 7 September 1999. Regulation of the Forestry Law.	Technical, regulatory, functional, and methodological direction of the State Forest Service.	State Forest Service.	National
Decree Law No. 212 of 8 August 2000. Coastal Zone Management. Ministry of Science, Technology and Environment.	Establish provisions for the delimitation, protection and sustainable use of the coastal and its protection zones.	The maritime-terrestrial strip of variable width, where the interaction of land, sea and atmosphere occurs through natural processes.	National
Decree Law No. 201 of 23 December 1999. On the National System of Protected Areas. Ministry of Science, Technology and Environment.	To establish the legal regime related to the National System of Protected Areas.	Protected areas.	National
Decree Law No. 190 of 28 January 1999. On biosafety. Ministry of Science, Technology and Environment.	To establish the general precepts that regulate the use, research, testing, production, import, and export of biological agents and their products, organisms, and fragments thereof with genetic information, as well as the release into the environment of biological agents, organisms, and fragments thereof with genetic data.	Agencies of the Central Administration of the State that have facilities and release areas.	National

Table A1. Cont.

Cuban Policies Applied by the National Council of Hydrographic Basins	Goal	Sector of Application	Scale
Decree No. 268 of 8 September 1999. Contraventions of forestry regulations. Council of Ministers	It establishes the applicable contraventions in forestry matters.	Natural persons, national or foreign.	National
Decree No. 327 of 11 October 2014. Regulation of the investment process. Ministry of Economy and Planning.	Regulates the essential elements of the investment process.	Ministry of Economy and Planning	National
Joint Resolution of 23 February 1996. Ministry of Agriculture. National Institute of Water Resources.	Elaboration of projects for hydro-regulating forest strips around reservoirs and riverbeds.	Ministry of Agriculture. National Institute of Hydraulic Resources.	National
Resolution No. 52 of 7 August 2007. Regulations of the National Council, Territorial Councils, and specific watershed councils. National Institute of Hydraulic Resources.	Put into effect the Regulations of the National Council, the Territorial Councils, and the specific River Basin Councils.	National Institute of Hydraulic Resources.	National, Provincial and Territorial
Cuban Standard NC: 93-01-206. 26 April 1996. Forest strips of the protection zones of reservoirs and riverbeds.	To arrange to prepare projects for hydro-regulating forest strips around reservoirs and riverbeds.	Ministry of Agriculture. National Institute of Hydraulic Resources.	National

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