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Research Article

Forensic Intelligence Management Applied to Legal Engineering

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Abstract

The forensic activities have evolved over time, many strategies, plans, and frameworks have been proposed in order to mitigate the complexity of forensic work and absence of resources to effectively well develop the crime combat and criminal persecution which reflects the constantly changing landscape within which forensic sciences operate. The forensic intelligence is still relatively new in the field of forensic science and the advances in legal engineering requires innovative techniques, methods, and strategies to combat local, regional, national, international crimes. This article provides an in-depth case study at Brazilian Federal Police in order to help academics, forensic scientists, forensic experts, police officers, managers, and policymakers in the legal engineering community to establish a holistic understanding and a realistic discussion that advances the frontiers of the forensic science. First, this article offers a scientific study and differentiation on the relevant definitions, such as intelligence, forensics, forensic intelligence, engineering, and legal engineering. Second, it depicts the scientific methodology and methods applied in this study. Third, it presents the application of forensic intelligence and its results in the legal engineering arena. Fourth, it reveals important discussions on the results obtained to solve the proposed problem including diverse social, economic, technological, and organisational activities that affect forensic management and legal engineering in many countries.

Keywords: Forensic Science; Forensic Intelligence; Criminalistics; Legal Engineering

Introduction

The forensic activities have evolved over time, many strategies, plans, and frameworks have been proposed in order to mitigate the complexity of forensic work and absence of resources to effectively well develop the crime combat and criminal persecution which reflects the constantly changing landscape within which policing operates. The forensic intelligence is still relatively new in the field of forensic science and the advances in legal engineering requires innovative techniques, methods, and strategies to combat local, regional, national, international crimes.

The problem to be addressed by this paper is using forensic intelligence to find out intelligence patterns and means to mitigate the high demand of forensic requests related to legal engineering in the forensic unit (SETEC/SR/PF/CE) at Brazilian Federal Police from 2014 to 2017. Therefore, it is necessary answering some questions: Is there any problem with the high number of open cases (pendency) involving legal engineering requests in SETEC/SR/PF/CE from 2014 to 2017? Do legal engineering requests involve all cities in the investigated Brazilian state? Is there a big amount of evidence types to investigate? Is it possible to establish a common triggering event to justify the high number of legal engineering requests? Are police officers and forensic experts carrying out their work properly and efficiently? In order to answer all these questions, this paper creates five hypotheses to be tested and assessed.

Therefore, this article provides a better understanding of forensic intelligence applied to legal engineering including diverse social, economic, political, technological, and organisational activi-

ties that affect policing in many countries. First, key definitions are presented to help academics, law enforcements, and practitioners upon core definitions such as intelligence, forensics, forensic intelligence, legal, and legal engineering. Second, the scientific methodology and methods used in this research are depicted with details upon the mode of research, mode of inquiry, research strategy, and data collection method. Thirdly, the forensic intelligence analysis and its results are presented based on the data analysis using tables, figures, summary of findings, and formulation of hypothesis to be tested, patterns, and intelligence actions. Fourth, some discussions emerged to explain the results when using forensic intelligence to analyse legal engineering requests. This paper also explores the application of forensic intelligence in order to help police officers, forensic experts, managers, leaders, decision makers, and scientists in the field of legal engineering establishing a holistic understanding and a realistic discussion that advances the frontiers of the forensic science.

Literature Review

Intelligence

Before to have a complete understanding of forensic intelligence, it is necessary to have a clear definition of the term "intelligence". Etymologically, the origin of the term intelligence comes from Latin "intelligentia" and means "the ability to acquire and apply knowledge and skills" [1] or "the ability to learn, understand, and make judgments or have opinions that are based on reason" [2]. Nonetheless, Oxford's and Cambridge's definitions are clearly generic and not contextualised enough for the purposes of this forensic study. Therefore, it is necessary research other definitions more contextualised to forensic approach.

One of the first scientific definitions of intelligence was provided by Random.

"Intelligence is the official, secret collection and processing of information on foreign countries to aid in formulating and implementing foreign policy, and the conduct of covert activities abroad to facilitate the implementation of foreign policy" [3].

The Random's definition has some weakness points in the forensic context; for example, it takes into account only: official use, processing on foreign countries and foreign policy.

The Central Intelligence Agency (CIA) in the United States provides a similar definition as can be verified as follows.

"Intelligence is the collecting and processing of that information about foreign countries and their agents which is needed by a government for its foreign policy and for national security, the conduct of non-attributable activities abroad to facilitate the implementation of foreign policy, and the protection of both process and product, as well as persons and organizations concerned with these, against unauthorized disclosure" [4].

CIA's definition is not focused for the forensic purposes once it presents the same drawbacks evidenced by Random. For example, it regards processing of information only about foreign countries and foreign policy.

In turn, the International Criminal Police Organization (INTERPOL) provides a definition of criminal intelligence analysis that fits well with the forensic purposes.

"Criminal intelligence analysis is an essential component of effective policing, at both the operational and strategic levels. Analysts study criminal data to identify possible trends, relationships or connections between different crimes in different places and use the analysis to support law enforcement activities" [5].

Beyond the international arena, the Brazilian Intelligence Agency (ABIN) highlights intelligence as follow and also fits well with the forensic purposes.

"Intelligence comprises actions of obtaining data associated with the analysis for its understanding. The analysis turns the data into an understandable scenario for understanding the past, the present and the perspective of how the future tends to shape itself" [6].

Therefore, in order to clarify and avoid any kind of misunderstanding upon the definition of intelligence, this study recognises that the INTERPOL's and ABIN's definitions are feasible to be used in forensic science and they fit very well with the forensic purposes.

Forensics

Etymologically, the origin of the term forensics comes from Latin "forensis, forum" and means "relating to or denoting the application of scientific methods and techniques to the investigation of crime" [1] or "scientific methods of solving crimes, that involve examining objects or substances related to a crime" [2]. Oxford's and Cambridge's definitions are well elaborated and suitable for

the general scientific environment. However, these two definitions can be more focused on the forensic setting. Therefore, this article presents other scientific definitions based on different authors and a final definition more applied for the forensic purpose is presented.

According to Mennell and Shaw [7], the use of forensics in policing tends to be reactive; that is, forensics are used in response to a crime or crime scene and then used in 'case-building'. Consequently, it is important to seek and exam other more focused definitions to forensics.

Rossy., *et al.* [8] exam the forensic definition based on its process and data analysis; however, they do not take into account the pieces of evidence and its relationships.

"Forensic processes are traditionally conceived to support and follow the investigative process from the crime scene to the trial on a case-by-case basis" [8].

In turn, De Alcaraz-Fossoul and Roberts [9] underline a very good and focused definition to forensics, but they do not take into account the logical evidence (e.g. data and information in computers and mobile devices).

"Forensics results from the analysis of empirical data and the application of scientific principles and disciplines that focus on the discovery and analysis of physical evidence" [9].

The Technical and Scientific Directorate at Brazilian Federal Police provides a relational view of forensic science and forensics.

"Forensic science, therefore, can be understood as science that assists justice in defining what is true, involving the application of scientific knowledge, technical or specialized in solving civil or criminal issues" [10].

Once the aforementioned definitions are not enough to embrace the aims of this article, it is presented a more objective and direct definition to forensics. This definition will be used throughout this article.

"Forensics is the use of specialised scientific practices from its procedures, techniques, methods, and theories to carry out the exam of evidences in order to investigate the materiality and authorship of delicts and solve crimes" (Author).

Forensic Intelligence

There are different definitions depending on each knowledge area and its application. As argued by Legrand and Vogel [7], whilst the definitions of 'forensics' and 'intelligence' separately describe two different terminologies in the fields of intelligence, forensic science, policing, and security their combination does not bring much more focus once they depend on the knowledge domains. In fact, some authors present their definitions to forensic intelligence focusing on data analysis and information processing, whilst other focus on strategic vision. For the purposes of this article, both approaches on the term forensic intelligence are suitable to apply in legal engineering; therefore, some definitions are presented as follows.

According to Ribaux., *et al.* [11,12] forensic intelligence uses data and information as a means to facilitate investigations and produce intelligence.

"Forensic intelligence is the accurate, timely and useful product of logical processing (analysis of) forensic case data (information) for investigation and/or intelligence purposes" [11,12].

De Alcaraz-Fossoul and Roberts [9] also bring a definition of forensic intelligence based on data but considering the physical evidences as a relevant factor.

"Forensic Intelligence is the knowledge that derives from data processing and information obtained from the examination of physical evidence in order to better understand the fact(s) of a crime" [9].

As per Legrand and Vogel [7], forensic intelligence also has the same vision focused on "data" mentioned by Ribaux., et al. but emphasising the connection with crime scene, material, and suspects.

"Forensic intelligence refers to the use of different forensic data to cross-reference and link together crime scenes, materials, and suspects" [7].

On the other hand, Baechler., *et al*. [13] provide a more strategically elaborated definition of forensic intelligence. They also consider the multi-case focus and the holistic vision.

"The fundamental principle of forensic intelligence is that, instead of treating each case individually with the aim of assisting the court (i.e. evidential focus), a multi-case focus and more ho-

listic approach based on the study of crime phenomena should be followed" [13].

Andrade., *et al*. [14] develop another strategic viewpoint to forensic intelligence taking into account the systematic process involving analysis, categorisation, and storage of trace pieces of evidence.

"Forensic intelligence is based on the ability to analyze, categorize, store, and relate trace evidences systematically and in a timely manner" [14].

Legal Engineering

There is no consensus about the definition of the term "legal engineering" [15-18]. As argued by Ritaine [16], the concept of legal engineering in stricto sensu is largely unknown by scholars, lawyers, and engineers. In lato sensu, the legal engineering is a composition of the terms "legal" (adjective) + "engineering" (noun). Therefore, it is important well analyse this term in the light of etymology, social sciences, and engineering.

The origin of the term "legal" comes from Latin "legalis" and means "appointed, required by the law" [1]. Legal has been developed as a "system of rules", as an "interpretive concept" to achieve justice, as an "authority" to mediate people's interests, and even as the command of a sovereign, backed by the threat of a sanction [16]. Legal reflects history because laws, statutes, contracts, and norms build up over time and change all the time. Thus, legal actions is paramount to engineering, because it involves many rules about companies, contracts, damage, civil and penal complains, properties, labours, and succession law [15,18].

On the other hand, the origin of the term "engineering" comes from medieval Latin "ingeniator" and means "the branch of science and technology concerned with the design, building, and use of engines, machines, and structures" [1]. According to the United Nations Educational, Scientific, and Cultural Organization (UNESCO).

"Engineering is the field or discipline, practice, profession and art that relates to the development, acquisition and application of technical, scientific and mathematical knowledge about the understanding, design, development, invention, innovation and use of materials, machines, structures, systems and processes for specific purposes" [19].

On the other hand, some authors use the definition of legal engineering with respect to engineering expertise within court proceedings. Others use the term to describe how law shapes social change using engineering as a mean. Depending on what side of the double proposal one stands, the choice is open to be applied on the engineering side, or on the legal side. As per Ritaine [16], very few authors combine the two-term "legal" + "engineering".

Smits [17] considers legal engineering as;

"The creation of legal structures that fulfill particular functional and practical purposes in engineering. It thus refers to the activity of engineers and lawyers that seek to find the best legal solution to a particular problem" [17].

A more specific vision of legal engineering (called as engineering forensics) can be seen at Brazilian Federal Police. According to DITEC [20], forensic experts work in legal engineering (engineering forensics).

"Using techniques of auditing and control, they carry out examinations relative to civil constructions, mainly evaluations of rural and urban estates, investigation of costs execution and quality of service checks, and price comparison. Investigations of crumbles and collapses are also attributions of this area" [20].

Methodology and Methods

Modes of Research

The literature presents two modes of research: mode 1 and mode 2 [21-23]. Mode 1 research draws attention to the creation of theoretical knowledge by detached traditional scientific research, usually based on natural sciences. Mode 1 is also called pure research, characterised by homogeneity, objectivity, experimentation, value-free, theory-based focus. Mode 2 concentrates on the creation of knowledge through direct involvement with social practise in the context of the application. Mode 2 research is also called applied research, characterised by heterogeneity, subjectivity, value based on social structures, diversity, social accountability, and reflexivity. Therefore, according to the characteristics presented, this study uses mode 2 as the mode of research.

Modes of Inquiry

Overall, there are two modes of inquiry in scientific research: quantitative and qualitative [21,22]. Quantitative inquiry refers to

approaches to empirical inquiry that collect, analyse, and display data in a numerical form. On the other hand, the qualitative inquiry is a set of actions toward strategies for conducting the inquiry that is aimed at discerning how human beings understand, experience, interpret, and produce the social world. Therefore, according to the characteristics presented, this study has a mixed approach (qualitative and quantitative) as the mode of inquiry.

Research Strategy

An essential step in the methodology is defining a strategy for inquiry. It was studied, analysed, and evaluated five research strategies: narrative research, phenomenology, grounded theory, ethnography, and case study strategy [21-23]. After examining these five qualitative strategies and their characteristics, this research will use the case study [21,24,25]. A case study can be seen as "an empirical inquiry about a contemporary phenomenon (i.e., "case(s)"), set within its real-world context" [25].

Therefore, a set of 213 cases in the field of legal engineering (i.e. agronomics, civil, electrical/electronics, and mechanical) and under the auspices of Brazilian Federal Police (BFP) were studied in this research. These cases were investigated by 8 (eight) police officers engineers, called as Federal Criminal Experts (FCEs), in the Forensic Unit (SETEC/SR/PF/CE) at BFP from January/2014 to December/2017.

Data Collection

This research created a new data collection process developed to multiple cases studies based on Creswell and Creswell [21] and Yin [25] which shows a sequence of data gathering activities that take place in research designs. Therefore, in this article, the data collection process is comprised of the following stages: gaining access and permission, sampling, collecting data, recording data, and storing data (see Figure 1).

As per Creswell and Creswell [21] a major strength of case study data collection is the opportunity to use many different sources of data (e.g. interviews, focus groups, documentations, audiovisual materials, etc.) describing multiple perspectives about the case. In the same vein, Yin [25] contends that the use of multiple sources of data in case studies enables a researcher to address a wide range of historical, attitudinal, and behavioural issues developing patter (converging lines of inquiry). In this research were used four different sources of data: documents, interviews, focus groups, and audiovisual materials.

Figure 1: Data collection process developed to multiple case studies.

Documents

Documentation used in this research was comprised of many forms – forensic reports, criminalistics system reports, police investigation reports, memoranda, field notes, hypertext documents in Internet sites, minutes of meetings, management records, as recommended by Creswell and Creswell [21], Stake [24], and Yin [25]. This method of data collection offered several advantages. First, it was used to verify the names, dates, sites, values, evidences, activities developed, resources and services, roles, responsibilities, origin, and destination of information, and so on. Second, it corroborated information from other sources (e.g. interviews and focus group). Third, it provided new information not collected from other sources.

Interviews

One of the most relevant sources of case study data is the interview [21,25]. Stake [24] states that two principal uses of case study are to obtain the descriptions and interpretations of others, and the interview is the main road to researchers discover and portray multiple realities.

Type of interview. In this research, it was chosen semi-structured in-depth interview [22,25]. An in-depth interview is a kind of interview that provides an opportunity to probe deeply a rich and real-life experience on the cases as well as open up new dimensions and insights from respondents [22,25]. Thus, interviews were used to understand the meanings that interviewees assign to

issues and situations in contexts that are not structured in advance. In turn, semi-structured is a kind of guided open interview where respondents are free to interrupt and be flexible toward issues being discussed [22,25]. Semi-structured interviews were conducted to provide consistent information that enabled comparability of data.

Identifying interviewees. 28 interviewees were chosen among FCEs, commissioners, and heads of police units (forensic unit, organised crime combat unit, financial crime combat unit) at BFP according to their engagement in the cases studied in this research.

Focus Groups

Interviews do not necessarily need to take place on a one-to-one basis, and for some types of investigations, focus groups can be very useful. Focus group takes the form of loosely structured discussion group held with selected participants [22,25]. The idea of a focus group in case study is to promote self-disclosure among participants concerning a specific issue on the case.

Therefore, a focus group was another data collection method chosen in this research due to several reasons. First, the interactions among participants provided extra information. For example, in the focus group for this research participants gave more details about police investigations, workplace in the field, forensic team's needs, and common barriers faced by federal criminal experts. Second, group discussions validated or invalidated the data collected individually in the one-to-one interview. For example, the mobilisations of resources and services mentioned individually during the interviews were confirmed during the focus groups. Third, it was useful to clarify and reconstruct individual viewpoints more appropriately. For example, some individual viewpoints about the evidences investigated in the cases were not so clear and were better explained during the focus group, such as details about the Rural Credit Notes (RCNs) and clarification of the evidences under investigation. Fourth, it facilitated an altogether deeper discussion generating collective critical reflections and more accurate and valuable data. For example, the focus groups provided fruitful discussions and critical thinking about the forensic management applied to legal engineering at BFP.

The focus group engaged 8 participants chosen among FCEs engineers, commissioners, and heads of police units (forensic unit, organised crime combat unit, financial crime combat unit) at BFP according to their engagement in the cases studied in this research.

Audiovisual Materials

The ability to record sound, images, and videos provides an outstanding benefit for case study research due to several reasons [21,22]. First, digital sources can store huge quantities of audiovisual data for access by large numbers of researchers. Second, researchers can use audiovisual materials to present new perspectives and stimulate discussion and debates between members of focus groups. In addition, participants talk much more about ideas taking into account audiovisual materials and this help to develop a clearer understanding of the activities developed on the case study [22]. Creswell and Creswell [21] recommend audiovisual materials as an elicitation technique to generate new insights and discussion on the case.

In this research were used several types of audiovisual materials, such as photographs, satellite image records, sound and videos records, specialised websites (e.g. Google Maps, Google Earth), and maps and reports produced by geographic information system – called INTELIGEO [26].

Forensic Intelligence and its results

After data collection, the next stage was to carry out the data analysis. Data analysis represents make sense of data [22]. If a researcher cannot make sense of the data that he/she is trying to manage then clearly it will generate difficulties for decision-making and strategies for interventions. The analysis carried out in this research began with multiple readings of the physical artefacts (i.e. audiovisual material and documents) followed by the interviews and focus groups. The investigative sequence of data analysis was a cycle as presented in figure 2 comprised of audiovisual materials, documents, interviews, and focus groups.

Figure 2: Investigative sequence of data analysis.

Initial intelligence analysis

In a first glance, the results on the data analysis offered an initial intelligence approach to mitigate the huge quantity of forensic demands. Firstly, it was categorised the forensic requests related to legal engineering in order to identify any initial pattern (i.e. convergence of information). Consequently, all 213 open requests (pendency) submitted to SETEC/SR/PF/CE involving the legal engineering were analysed. Secondly, after this initial intelligence analysis initiative, the next step was requested forensic support specifically to the most impacted legal engineering area via national recruitment to the National Institute of Criminalistics (NCI). NCI is part of the Technical and Scientific Directorate and it is the central criminalistics headquarter at BFP and had dozens of FCEs engineers to support other forensic units in all 27 Brazilian states.

In order to find out solutions to the presented problem, it was vital to create hypotheses to be verified, recognise patterns, and propose intelligence actions as follows;

- **Hypothesis #1:** There is a complex problem with all 213 open cases (pendency) involving legal engineering requests in SETEC/SR/PF/CE from 2014 to 2017.
- **Pattern #1:** There were 8 FCEs engineers in SETEC/SR/PF/CE. They worked with 4 major types of legal engineering investigations (i.e. agronomics, civil, electrical/electronics, and mechanical). It was identified that 174 out of 213 forensic requests were from agronomics engineering. Therefore, as presented in figure 3, the most impacted area in legal engineering was agronomics engineering. The other areas of legal engineering in SETEC/SR/PF/CE were under control. As result, 81.69% of all legal engineering forensics investigations were from agronomics engineering and SETEC/SR/PF/CE, at that period, had with only one FCE to carry out all agronomics demands.
- **Intelligence Action #1**: Based on the initial data analysis, the hypothesis was false. The high demand was only focused on agronomics engineering, not in all areas of legal engineering as supposed in the hypothesis. Consequently, the head of SETEC/SR/PF/CE requested emergency support via national recruitment to National Institute of Criminalistics (NCI) in order to attend the forensic requests in the specific field of agronomics engineering. Nevertheless, the input of requests related to agronomics engineering was greater than its output and the production of forensic reports was below to desirable, even with NCI support.

Legal Engineering Area	Quantity
Agronomics	174
Civil	29
Electrical/Electronics	9
Mechanical	1
TOTAL	213

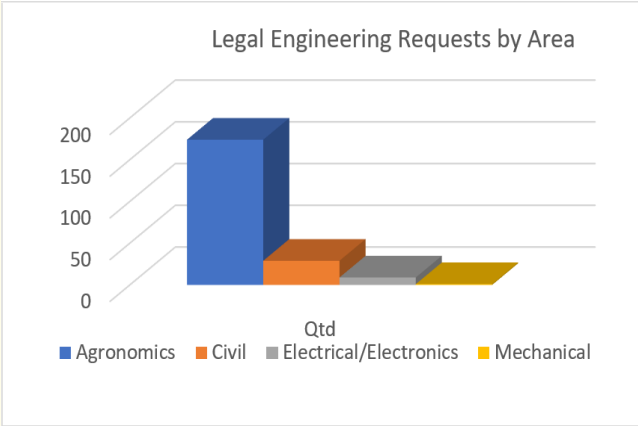

Figure 3: Recognised Pattern #1 (Legal Engineering Requests by Area).

In-Depth intelligence analysis

The Intelligence Action #1 did not solve the problem of high demand related to legal engineering. Therefore, it was necessary to advance in the data analysis. It would be necessary to develop an in-depth data analysis of the 174 forensic requests involving agronomics engineering and, based on this analyse; it would be possible to find out other patterns.

- **Hypothesis #2:** The forensic requests in SETEC/SR/PF/CE related to agronomics engineering involve the majority of the cities in Ceará state that has 184 cities.
- **Pattern #2:** All sites under investigation were concentrated on the rural zone of 4 cities Iracema, Tabuleiro do Norte, Russas, Morada Nova, in Ceará state (See Figure 4).
- **Intelligence Action #2**: Based on the data analysis, the hypothesis was false once the forensic requests related to agronomics engineering involved only 4 cities in Ceará state. Therefore, the forensic and police resources should concentrate their efforts in these 4 cities.
- **Hypothesis #3:** There was an immense amount of types of forensic evidences and their occurrences in the agronomics engineering requests in SETEC/SR/PF/CE.
- **Pattern #3:** There were only 18 different types of evidences: caprine and ovine matrix, land cleaning, bovine matrix, fence, grass, sorghum, ovine and caprine kraal, silage, animal trac-

tion trolley, wooden stockyard, ration, vaccine and medication, handling centre, coach, stable, shed, manioc plantation, and mineral salt. This research identified the occurrences of each type of evidence in all 174 requests. Thus, analysing the 174 requests, the total of 307 occurrences were found. However, as represented in figure 5, there were 288 occurrences out of 307 in total related to only 8 types of evidences: Ovine and Caprine Matrix, Land cleaning, Bovine Matrix, Fence, Grass, Sorghum, Ovine and Caprine Kraal, and Silage. Consequently, 93.81% of all occurrences were related to only 8 types of evidences.

- **Intelligence Action #3**: Based on the initial data analysis, the hypothesis was false once there was only a short amount of types of forensic evidences and their occurrences in the agronomics engineering requests. Therefore, the forensic and police resources should concentrate their efforts in these 8 types of forensics evidences.
- **Hypothesis #4:** There was a common triggering event in the agronomics engineering requests in SETEC/SR/PF/CE.
- **Pattern #4:** It was found out a common a triggering event throughout the data analysis – the Rural Credit Notes (RCNs) financed by Brazilian Northeast Bank (BNB). RCNs were financed by BNB without check of the guarantees with small and medium farmers in the rural zone of the cities of Iracema, Tabuleiro do Norte, Russas, and Morada Nova. There were strong suspicions of frauds involving these RCNs with the participation of BNB staff, local farmers' cooperative staff, and farmers.
- **Intelligence Action #4:** Based on the initial data analysis, the hypothesis was true since there was a common triggering event in the agronomics engineering requests – the RCNs. Therefore, the forensic and police resources should concentrate their efforts in the process of concession of RCNs by BNB.
- **Hypothesis #5:** All data and information in the RCNs sent as part of the agronomics engineering requests to SETEC/SR/PF/CE were checked previously by police officers in the sites under investigation.
- **Pattern #5:** FCEs in SETEC/SR/PF/CE were demanded to undertake their exams and analysis before an initial police investigation. In addition, several times the data into the RCNs were false or incomplete. For example, farmers were not found, the site of the farm was not localised, the financed item (evidence) did not correspond to the type of work developed in the farm. This kind of request demanded a vast amount of forensic resources (e.g. human, logistics, financial) beyond be time-consuming.
- **Intelligence Action #5:** Based on the data analysis, the hypothesis was false once the data and information in the RCNs were not checked previously by police officers. Consequently, the police should check all data and information in the RCNs before sent them to SETEC/SR/PF/CE. Therefore, it was essential to carry out a qualitative data analysis in order to find out concepts and categories to create an investigative form that would be filled by police officers in the field before sending any forensic request to SETEC/SR/PF/CE.

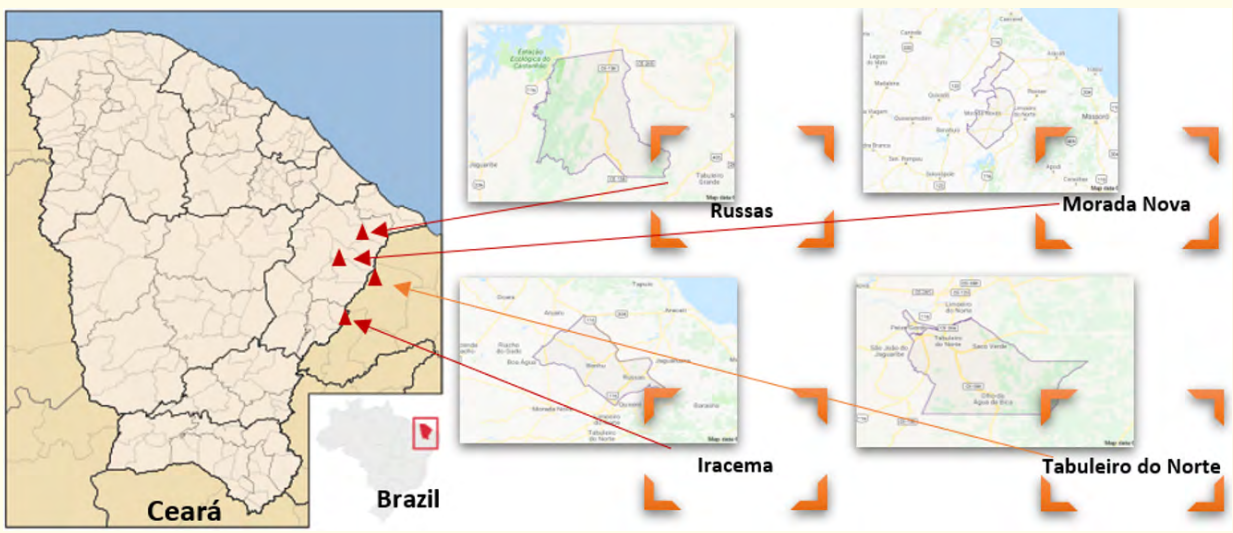

Figure 4: Recognised Pattern #2 (Cities).

From qualitative data analysis emerged codes (concepts) that were clustered in themes (categories). Some subcodes and codes were produced for recurrent patterns in data, analysed the subcodes for codes and after codes for themes and emerging theoretical insights, and then returned to the data for further coding and analysis in the light of these emerging theoretical insights. In this

Types of evidences	Occurrences (#Times)
Ovine and Caprine Matrix	55
Land cleaning	46
Bovine Matrix	45
Fence	44
Grass	40
Sorghum	30
Ovine and Caprine Kraal	16
Silage	12
Animal traction trolley	5
Wooden stockyard	4
Ration	2
Vaccine and medication	2
Handling centre	1
Coach	1
Stable	1
Shed	1
Manioc plantation	1
Mineral salt	1
TOTAL	307

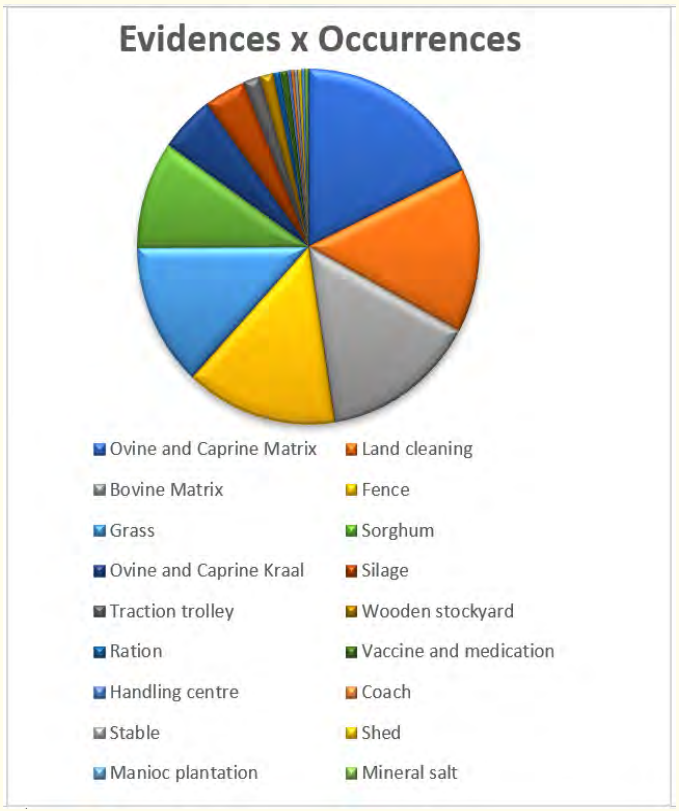

Figure 5: Recognised Pattern #3 (Evidences x Occurrences).

study, the criterion for what constitutes a theme was its relevance within the analysed case as an exploratory factor rather than its frequency, as advocated by Corbin and Strauss [27]. Many subcodes appeared in more than one code. Through a critical reflexion process using member checking [21], codes were reassessed, merged or expanded as appropriated for the best location in building themes. For example, the sentences "Rural Credit Notes (RCNs)", "fraud", "animal evidence", "vegetable evidence", "man-made evidence" appeared several times in different places as subcodes, then they were reassessed and relocated in best places into the appropriated theme. This continuous comparison among subcodes, codes, and themes continued until "saturation" was reached and no new theme emerged [27]. In total, the 174 open cases involving agronomics engineering generated 5 themes and 17 codes (see Figure 6).

Based on this qualitative data analysis, the head of SETEC/SR/PF/CE together with FCEs, commissioners and all stakeholders created a form to be filled by police officers before request any forensic exam. This form should contain at least the main categories and concepts evidenced in Figure 6.

Discussion

This article provided a better understanding of forensic intelligence applied to legal engineering in SETEC/SR/PF/CE at Brazilian Federal Police and several important implications emerged from this study. From the forensic intelligence application on the studied case, some factors became evident as follows:

- The problem with the set of 213 cases involving the legal engineering requests from 2014 to 2017 in SETEC/SR/PF/CE was mainly focused on agronomics engineering (81.69% of forensic requests to legal engineering).
- There was a huge lack of specialised human resources to carry out all forensic requests involving agronomics engineering in SETEC/SR/PF/CE since there was only one Federal Criminal Expert with this specialty.
- The forensic requests related to agronomics engineering in SETEC/SR/PF/CE involved only 4 cities Iracema, Tabuleiro do Norte, Russas, and Morada Nova that were in the same micro-region of Ceará state.
- The request of emergency support by SETEC/SR/PF/CE via national recruitment to National Institute of Crimi-

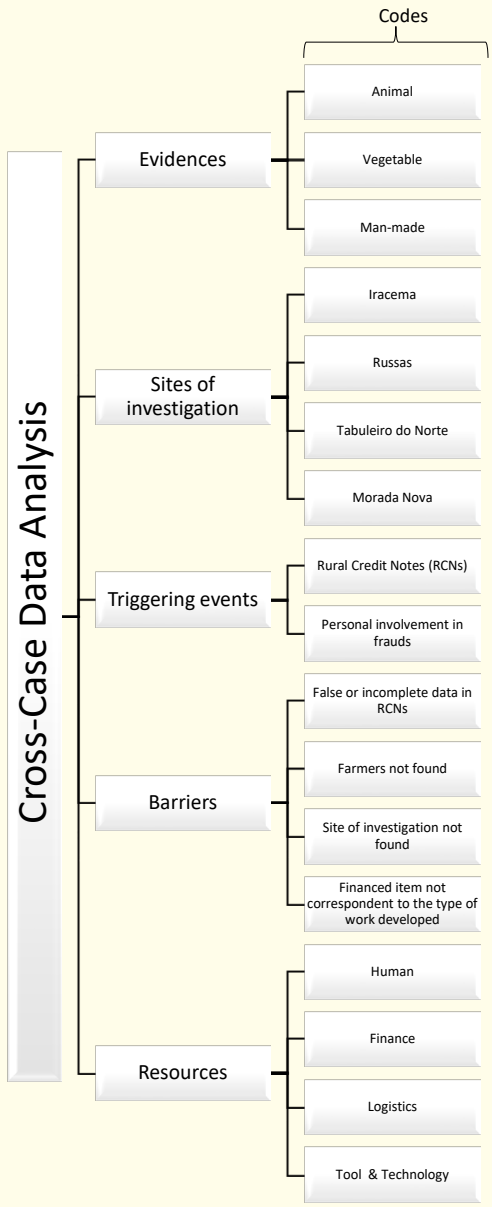

Figure 6: Resulting themes and codes after the cross-case data analysis.

nalistics (NCI) did not substantially to reduce the pendency involving agronomic engineering once the input was greater than the outputs.

- The occurrences of evidences in all 174 forensic requests involving agronomics engineering were concentrated in 18 types.
- There was a common triggering event in the agronomics engineering requests to SETEC/SR/PF/CE, the Rural Credit Notes (RCNs) financed by Brazilian Northeast Bank (BNB). Consequently, there were strong evidences of fraud in these RCNs.
- All data and information in the RCNs sent as legal engineering requests to SETEC/SR/PF/CE were not checked previously by police officers in the sites under investigation. This lack of investigation demanded a vast amount of forensic resources (human, logistics, tools & technologies, and finance) beyond time-consuming.
- It was crucial to create a form in the specific field of agronomics engineering to be filled by police officers before any forensic request.
- It was identified intelligence patterns and means to mitigate the high demand for forensic requests related to legal engineering in the forensic unit (SETEC/SR/PF/CE) at Brazilian Federal Police.
- The application of the five Forensic Intelligence Actions throughout 6 months provided a reduction rate of 97.13% (174 forensic requests to 5 forensic requests) involving open cases (pendency) in the agronomics engineering.
- The total estimated reduction of operational costs was US$ 370,272 involving salaries per day by FCE and FPA during the mission, charges per day by FCE and FPA during the mission, police car gas during the mission, flight tickets by FCE from INC during the mission, salaries per day by FCE to prepare the forensic report after the mission). The estimated financial reduction was about 2,128 US$ by forensic request and asset recuperation involving million dollars.
- Three large police operations engaging dozens of police officers were carried out from 2014 to 2017 based on the forensic intelligence analysis developed in this scientific research.
- Forensic intelligence actions were quite effective and efficient to mitigate forensic requests, time, resources (e.g. human, financial, material, logistics).

Conclusions

This article provided a better understanding of forensic intelligence applied to legal engineering. It explained the core definitions such as intelligence, forensics, forensic intelligence, legal, and legal engineering. It revealed the complex problem involving the huge amount of legal engineering requests faced by forensic unit (SETEC/SR/PF/CE) at Brazilian Federal Police. Based on scientific methodology and methods it was possible to identify a scientific path to solve the problem. Thus, the results using forensic intelligence were evidenced via data analysis using tables, figures, summary of findings, formulation of the hypothesis, patterns, and intelligence actions. In turn, some discussions emerged to explain the results and corroborate the useful application of forensic intelligence in legal engineering. The problem to mitigate the high demand for forensic requests related to legal engineering in the forensic unit (SETEC/SR/PF/CE) at Brazilian Federal Police was solved. The reduction rate of 97.13% was obtained after the ap-

plication of forensic intelligence; therefore, the aim of this scientific study was effectively and efficiently achieved using forensic intelligence applied to legal engineering.

At last but not least, this research provided a financial reduction about 2,128 US$ by forensic request, the total estimated reduction of operational costs was US$ 370,272 and asset recuperation involved million dollars.

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