Uncertainty in Forest Management

An exploratory study on uncertainty in European forestry over time
Based on differentiation of its sources, types, and categories

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For quality of life

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Alhamdulliahi robbil alamiin….

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SUMMARY

Uncertainty in decision-making is a fact that cannot be avoided by any individual and/or organization. Due to the long time horizon characteristic of forest sector, uncertainty in forestry forms a major challenge to the decision makers. Previous research suggests that decision maker face different kinds of uncertainty. Consequently, differentiation of uncertainty is required in order to better cope with the issue. Much attention has been devoted to this topic, but it has rarely been carried out in the forestry sector. Differentiation of uncertainty and time horizon issue has a potential role in forestry. Therefore, the objective of this research is to explore the development of uncertainty over time. The research was carried out by differentiating forestry decision makers' uncertainty in a period of time, into several dimensions (based on its sources, types, and categories). Data was collected by using content analysis method and analyzed further by employing several statistical techniques. The results indicated that the decision makers experienced both uncertainty and certainty in the similar rate. The result also showed that there was no correlation between uncertainty development and time horizon. The analysis was further carried out to the dimensions of uncertainty, where inadequate understanding was found to be the most frequent source that causing uncertainty. On the other hand, state uncertainty was the most frequent type of uncertainty that experienced by the decision makers, and they were also most uncertain about the natural environment.

Another analysis was carried concerning the correlation between dimensions of uncertainty and time. The results showed that sources and types of uncertainty did not have any correlation with time. While natural environment, market, and internal organization from the categories of uncertainty dimensions, does have correlation with time, however, from these categories only natural environment that has positive correlation. An additional analysis showed significant differences between uncertainties experienced by each author, also in terms of its dimensions. The theoretical framework adopted in this study, well explained the derivate findings.

The results of this study suggest the significance of differentiating uncertainty based on its sources, types, and categories as well as identifying rigorous aspects of uncertainty. Further research is suggested on the interaction between dimensions of uncertainty, and also the influence of personal characteristics to uncertainty which being experienced. And, further investigation is suggested to analyze the influence of organization divisions in determining the kind of uncertainty that occurred.

Keywords: content analysis, dimensions of uncertainty, time horizon, uncertainty

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1 Introduction

1.1 Background

Decision-making is a continuous process that cannot be avoided by any individual and/or organization. In decisions, individual and/or organization respond based on their judgments. These judgments, based on the availability of information to the decision makers can vary widely from case to case. This condition in the end turns decision-making in to a matter "a choice of alternatives", which is associated with the highest utility for the known information (Conrath, 1967; Simon 1978). Based on the known information, a decision maker is able to describe or interpret the environment (socioeconomic, organization structure, ecology, technology, etc.) (Simon, 1978). However, a problem all decision makers face, is imperfect information that leads to the inability to predict the environment where decisions should be made, hence is termed an uncertain condition or "uncertainty" (Conrath, 1967). For most decision makers today, uncertainty in decision-making is inextricably tied to the complexities of the decision environment. According to theorists, much of the uncertainty that surrounds behavior of complex systems is intrinsically irreducible by science (Borchers, 2005).

Uncertainty is a problem for every decision makers. However, in sectors with long time horizons uncertainty forms a major challenge. In these sectors, decision makers usually have to consider far off future development in current decision-making. But practices face difficulties in forecasting the future, i.e. the further into the future, the more variables may interact and the more uncertainty arises (Hoogstra and Schanz, 2008a). Forestry is one of these sectors that deals with long time horizons: e.g. the commercial tree growing of typical coniferous species in U.K., which take 50 – 70 years to grow before its final felling. For hardwood species, the planning horizon is often much longer, with felling cycle of 100 years or more (Convery, 1973). The long range of production period comes with high uncertainties that are faced by forestry decision makers such as uncertainty in (1) the natural environment; where the major hazard is climatic (particularly extreme events, for example: droughts, floods, lightning strikes or hurricanes) and biotic (insects, fungal or viral pathogens or browsing animals), (2) technological advances; such as the use of helicopter in harvesting isolated areas which is something, that has never been predicted some decades ago, (3) dynamics of human behaviors; like arson or accidental fires, illicit felling and illegal encroachment, (4) forest products market, e.g. the timber market, which is a subject to unexpected surges and collapses to unexplained fluctuations, to expansion and recession, and to general trends, which change its general character in the long term, (5) political environment; within a temperate forest rotation many governments come and go, some policies are succeed while others are forgotten and pass into oblivion, tax regimes are

mooted, discussed, implemented and suppressed, national forest services are set up, expanded, curbed or privatized (Price, 1989), (6) the internal environment/organization which consist of those relevant physical and social factors within the boundaries of the organization. There can also be a particular decision making unit which has direct effect on consideration for related decision making; as one can think of changes of structural functions in organizations due to changing ownership (Duncan, 1972). These uncertainties, which faced by decision makers, in this study will be termed as categories of uncertainty.

1.2 Problem statement

Research on uncertainty reached a peak of popularity in the 1970s and has since fallen off dramatically. Perhaps one reason for this decline in interest was that the results of previous research could not be easily interpreted. Therefore precision is needed in defining, using and measuring the construct of uncertainty (Milliken, 1987). Many classifications of environmental sectors to construct uncertainty, are based on conceptual works of some 20 – 40 years ago, and consequently, some of these construct of uncertainty that were identified are no longer in use (Priem, et al., 2002). Besides, past research suggests that there are problems with the existing construct of uncertainty (Milliken, 1987). Therefore, there might be a need to formulate a new construct that considers important aspects in uncertainty.

An early attempts to analyze the construct of uncertainty has been carried out by Duncan (1972), which discover that individuals experiencing uncertainty due to the lack of information, imperfect understanding regarding the outcome of an action, and the inability to assign probabilities of alternative outcome. Lipshitz and Strauss (1997) term this rationale as sources of uncertainty. However, Milliken (1987) suggest that it is not only important to understand what the particular source of uncertainty is, in order to identify the domain of the environment which decision makers are uncertain about, but maybe it is also important to understand the type of uncertainty, where its focuses is on delineating the nature of the uncertainty being experienced. Distinguishing types of uncertainties is important since decision makers encounter different types uncertainties and respond differently (Milliken, 1987; Lipshitz and Strauss, 1997). On the other hand, many attempt to construct the important aspects of uncertainty environment by classifying them into groups, are based on the works of some 20 – 40 years ago, consequently, some of these classification are no longer in use at the present (Priem et al., 2002). Therefore a new and/or a more general classification of these groups are required, where in this study it will be termed as categories of uncertainty.

These constructs of uncertainty might lead decision maker to better understand the uncertainties they faced. However, decision maker have to be aware of changes over time that possibly occurred in their environment, which can easily influence the degree of uncertainty they experienced (Ondersteijn et al.,, 2006).

In forestry, research concerning development of uncertainty and its differentiations over time has never been carried out. Still we know that the many changes, which have occurred in the last decades is not only within the forestry sector, but also in the environment infiltrating forestry to a large extent. Convery (1973) stated that in the Middle Ages, forest preservation was intended to provide hunting pleasure for nobles, with the subsidiary functions of producing mast and fuel. As forest clearances continued, populations expanded with a simultaneous increase in wood demands for fuel and construction. Concerns

gradually came to focus on the problem of re-creating the forest to assure a wood supply for future generations. More recently, a multi-functionality concept has emerged in the sector of forestry, where forests are preserved for its function, e.g. watershed, carbon sequestration, recreation, wildlife habitat, supplier of timbers, etc, the globalization era has changes the boundaries and complexities of environment into a more dynamic and more complex environment than the past.

Forestry, as any other sector has to adapt to environment to remain viable, and the essential part of this adaptation process involves with uncertainty (Ferris, 1977). Thus, to adapt to the environment, it is important to know the developments which occurred with decision makers uncertainty in relation to the aspects of environment, further leading to the need for differentiation of uncertainty base on its sources, types, and categories (during this research this will be termed *"dimensions of uncertainty"*) in order to differentiate methods of coping. Adaptations to environmental changes are intended to avoid losses caused by the undesired effects of uncertain changes. Therefore the study on development of uncertainty and its dimensions over time should be done in order to contribute to development of strategies for coping with uncertainties in forestry.

1.3 Objectives and Research Questions

This research focuses on the development of uncertainty and its dimensions in forestry over time, in order to generate knowledge that can contribute to further research on strategies for coping with uncertainty in forestry.

Research Questions:

1. To what extent is forestry uncertain?
2. What sources, types, and categories of uncertainty do exist in forestry?
3. Has does uncertainty develop over time?
4. How do the dimensions of uncertainty develop over time?
5. What are the consequences of these developments for forestry decision-making?

1.4 Structure of the Report

This report contain chapter one, which set out the issue concerning uncertainty that need to be addressed in forestry sector. The formulated research objectives and questions than presented in the following section. Chapter two introduces the relevant theories from previous research, which also used to construct the framework in carrying out this study.

Chapter three introduces the research methodology used in this research, by firstly discussing the approach, and followed by the reasoning of case study selection. In the following section, overview of the used data collection methodology is presented, and accompanied with its procedure. Finally, this chapter is ended with the section regarding the statistical analysis that appropriate for this research.

Results of the data analysis is presented in chapter four, which contain the overview of forestry decision makers uncertainty and its dimensions, where each is followed by the presentation of their significances regarding dominant frequency, and the results of correlation analysis concerning development of uncertainty, and its dimensions over time. The last section of the fourth chapter is presenting the over view of the main results.

Based on the findings from this research, the fifth chapter of the report is discussing the development of uncertainty over time, which followed by the dynamics of its uncertainty dimension. The section after

then discussing the coping strategies for the most frequent dimensions of uncertainty, and then followed by the explanation of limiting factors in this research, and suggestions for further research.

Finally, conclusions that can be drawn from the results of the statistical analysis are found in chapter six.

2 Theoretical Background

This chapter underlines the theoretical definition and framework used in this repot. The various definition of uncertainty is introduced in the first section, which followed by the dimension of uncertainty that consist of sources, types, and categories of uncertainty. The last section then presented the over view of strategies to cope with uncertainty.

2.1 Defining Uncertainty

Uncertainty is a prominent concept in decision making studies (Lipshitz and Strauss, 1997), however, it can be defined in several different ways, there is no standardized definition to define uncertainty, every disciplines has their own definition, even within the same discipline various definitions are existing.

The Oxford dictionary defines uncertainty as "the state of being not completely confident or sure" (Oxford English Dictionary, 2007). This definition describes uncertainty in general and does not specify a certain field of expertise. Some economists such as Knight (1921) in the other hand, view it as the result of incomplete knowledge and divide it into *measurable or objective uncertainty*, where the probabilities of alternatives are known, which is called *"risk"*, and *unmeasurable or subjective uncertainty* where the probabilities of alternatives are unknown, defined as *"uncertainty"*. While some other economist blurred this distinction and used these two terms interchangeably, which resulted from three basic interpretation of risk in relation to uncertainty. The first interpretation is related to all modalities of uncertainty, where uncertainty is reducible to risk. The second interpretation is in line with Knight (1921) differentiation, where risk is defined as *objective uncertainty* and uncertainty as *subjective uncertainty*, and the third interpretation of risk is related to the possible negative consequences of a certain action, which means all modality of uncertainty can imply risk (Young, 2001).

Vercelli (1998) and Young (2001) attempt to clarify the situation by divide uncertainty into two categories: (1) hard uncertainty which define situations where; a) the set of all possible outcomes alternative or future states is unknown, or b) where the outcomes alternative are known, but the distribution of its probability is unknown or not perfectly definable due to the lack of reliable information, and (2) soft uncertainty or risk which refer to situations where; a) the set of all possible outcomes alternative is known and, b) the probability distribution of all possible outcomes alternative is also known. In other words, in this definition uncertainty is defined as part of uncertainty. Faucheux and Froger (1995) define the above distinction as a situation that lies between ignorance and certainty (see figure 1).

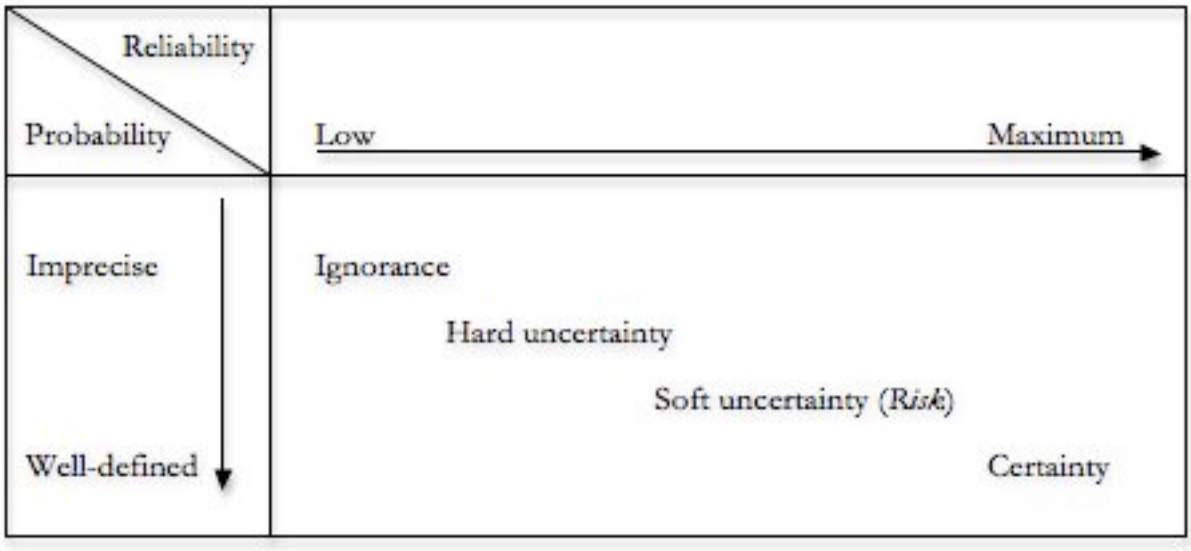

Figure 1 Modalities of uncertainty (Faucheux and Froger, 1995)

However, even though Young (2001) differentiate uncertainty into *hard uncertainty* (uncertainty) and *soft uncertainty* (risk) as mentioned before, to keep matters clear, in his works the term "risk" imply to the negative consequence of an uncertain action. In relation to this, Knight (1921) emphasizes this common ambiguity, where risk is ordinarily used to describe undesirable consequences of uncertain action, and uncertainty refers to the favorable outcomes. He argue that this ambiguity needs to be clarified in order to preserve the distinction, by constantly using the term "*risk*" in the connection of measurable or objective probabilities, and "*uncertainty*" in relation to immeasurable or subjective probabilities.

In the matter of the distinction of uncertainty as objective probabilities and risk as subjective probabilities, other authors reject this distinction and use the terms risk and uncertainty interchangeably, because when it is put to use, all probabilities are subjective (Duerr, 1979). Further, by considering different definition of uncertainty and its related terms e.g. uncertainty, risk, ambiguity, etc Lipshitz and Strauss (1997), states that uncertainty can be defined in terms of action, uncertainty then is a *"sense of doubt that blocks or delay action"*, which assumes that decision makers are blocked or delayed by doubts about outcomes, situation, and alternatives. In this approach, risk category does not exist.

Similarly to Lipshitz and Strauss (1997), Milliken (1987) summarizes the commonly cited definitions of uncertainty, and present three most common definitions citied by organization theorist. There are:

1. The inability to assign probabilities as to the likelihood of future events
2. The lack of information about cause effect relationships
3. The Inability to predict accurately what the outcomes of a decision might be

And he argued that these definitions are adaptations from uncertainty definition offered by psychology and economics theorist. He defined uncertainty as *"an individual's perceived inability to predict something accurately"*. This suggests that an individual experiences uncertainty because they perceive themselves to be lacking adequate information to forecast accurately or because the individual feels unable to differentiate between relevant and irrelevant facts. This definition indicates that uncertainty is a characteristic of a person. It's a decision maker's state of mind in perceiving a certain condition, where as the view of different decision makers to the same forecast can be diverse to each other (Duerr, 1979). It is arising from the inability of an individual to control the situation and also him self (Downey and Slocum, 1975).

The definition of uncertainty by Milliken (1987) however has a strong focus on the future time "predict". Uncertainty is however not always about the future, it can also refer to the past or the present, for

example when knowledge about the present situation or the past is not clear (Hanf, 1986 in Hoogstra and Schanz, 2008a). Referring to the uncertainties of the past and the present, it will be a reference about the uncertainties about the future, and in most of the practical situation, we have noticeably more information about the past and the present then about the future, therefore the former is considered to be more certain than the latter (Pomerol, 2001).

2.1.1 Definition of Uncertainty in Forestry

As mentioned before, various definitions of uncertainty exist even within the same disciplines, these variations also captured in forestry sector. As an overview, definitions of uncertainty and its related terms from forestry literatures compiled by Hoogstra and Schanz (2008a) is presented in table 1.

Resolving this problem of definition is neither critical nor essential in this research. Therefore, it will not be focusing on the aspect of these differentiations, and will take an uncertainty definition proposed by Hoogstra and Schanz (2008a), where uncertainty is defined as "*the perceived inability to know or predict something accurately",* and risk is seen as the uncertainty of outcome, weather it is positive or negative.

Defining uncertainty as the perceived inability to know or predict something accurately has several essential features; (1) it is depart from the classical notion where uncertainty is considered to be an individual characteristic, different individuals may experienced different uncertainty in an identical situation (subjective point of view), therefore this definition did not distinguish uncertainty from risk (which is considered as objective matters by some authors, as mentioned in the previous section) , but consider risk as a part of uncertainty, (2) based on time aspects, it is not only focus on future uncertainty, but also consider past and present uncertainty, (3) in terms of decision making, this definition not only represent an action, but also the absence of action, because it is representing the state of mind of a decision maker.

Table 1. Conceptualization of uncertainty and related concepts in forestry literature (Hoogstra and Schanz, 2008a)

Author(s)	Concept	Definition
Davis and Johnson (1987)	Risk	Whenever probabilities can be assigned to the state of nature by subjective or objective means
	Uncertainty	Uncertainty exists if no probabilities can be assigned to the different states of nature
Duerr et al. 1979	Uncertainty	Uncertainty is the holding of anticipations that are not single valued.
	Risk	The terms uncertainty and risk are used interchangeably.
Kangas and Kangas 2004	Risk	Under risk and uncertainty, the state of nature that would prevail is not known with certainty.
	Uncertainty	Under risk, the probability of each state of nature occurring, and, correspondingly, the probability distribution of consequences are known; otherwise, the decision is made under uncertainty.
Leuschner 1984	Certainty	Certainty exists if there is only one outcome for each alternative.
	Risk	Risk exists if a probability distribution can be attached to the different states of nature and hence to the different outcomes
	Uncertainty	Uncertainty exists if there is no information about the probability distributions of the states of nature, not even a subjective estimate of the probabilities can be made by experts.
Oesten and Roeder 2001	Certainty	Outcome of a decision is unambiguous and known, complete information is available.
	Uncertainty	Outcome of a decision is ambiguous and only partly known; only incomplete information is available.
	Risk	A degree of uncertainty in which the possible outcomes of a decision and the objective probabilities of these outcomes are known.
	Ambiguity	A degree of uncertainty in which possible outcomes are known, but not the objective probabilities of these outcomes.
	Ignorance	A degree of uncertainty in which outcomes and probabilities of outcomes are unknown (complete uncertainty).
Price 1989	Ignorance	We know nothing.
	Uncertainty	We know the range of relevant states of nature and therefore what outcomes are possible but not the relative probabilities of each state of nature.
	Risk	This is distinguished from uncertainty by knowledge of the probability of each state of nature.
	Certainty	We know which state of nature will eventuate and precisely what the outcome of a strategy will be.
Worrell 1959	Risk	A risk is an outcome whose probability of occurrence can be established in a quantitative manner.
	Uncertainty	In contrast, uncertainty is a variable factor or outcome whose probability of occurrence cannot be established in a quantitative manner.

2.2 Dimensions of Uncertainty

Besides raising the question whether individuals define uncertainty differently with each other, the existence of different definitions of uncertainty also raises a question that requires attention. This question is whether each definition is essentially a restatement of the same point of view, or represents a

qualitatively different dimension of uncertainty (Milliken, 1987; Lipshitz and Strauss, 1997). Past research suggest that there are problems with the existing concepts in defining uncertainty, which partially caused some confusion in the results of the previous research and, by seeing the lack of relationship between the concepts, suggest possibilities that each concept defines several dimensions of uncertainty. Therefore, there is a need to differentiate uncertainty based on its nature and in order to better cope with it (Milliken, 1987; Ondersteijn, et al., 2006). Since different dimensions of uncertainty need to be coped with different strategies (Milliken, 1987; Lipshitz and Strauss, 1997).

Differentiation that exists in previous research generally concerns the "source of uncertainty" and the "type of uncertainty", despite these existing differentiations, some confusion in their definition still occurs, where previously researchers used the terms differently to define similar items. For this study and in order to avoid such confusion, source of uncertainty will be defined as "the reasons that cause uncertainty" (e.g. insufficient data on amount of leaves on each tree in a forest, to determine the exact ability of regional carbon sequestrations), which has focus on the possible rationale of the experienced uncertainty (Lipshitz and Strauss, 1997). Type of uncertainty is defined as "the circumstance of uncertainty which are possibly experienced by decision makers" (e.g. uncertainty of forest future condition), which focus on delineating the nature of uncertainty being experienced (Milliken, 1987). In previous studies, there is also a frequent research carried out concerning uncertainty of external and internal aspect of decision making environment, but this dimensions of uncertainty has not been termed consistently, therefore in this study these aspects will be termed as "categories of uncertainties", where it is defined as "the aspect of environment where uncertainty is experienced" (e.g. occurrences of cyclone, changing human needs on forest products, etc). The category of focus will be the identification of the domain of the environment (internal and external) for which the decision maker has uncertainties.

2.2.1 Source of Uncertainty

Past research on uncertainty has often neglected the classification of sources of uncertainty. This leads to hindering the determination of proper strategies to better cope with uncertainty (Priem et al, 2002). Therefore, it's essential to identify the sources of uncertainty in order to properly conceptualize the strategy to cope it.

Source of uncertainty in this study are defined as "the reasons that cause uncertainty". Duncan (1972) identified what he considered as sources of uncertainty by focusing on the lack of information, which is explained further by Lipshitz and Strauss (1997) as a three-fold rationale in the classification scheme of uncertainty. The first rationale refers to information deficiency on environmental factors related to a certain state of decision-making condition. The second rationale relates to the absence of knowledge regarding the consequence of a certain decision, in terms of the loss that will be suffered by a decision maker if the taken decision is incorrect, or the advantages that will be received if the decision is right. It thus indicates that at times, decision makers do not experience uncertainty because of the lack of information, but because they are overwhelmed by the abundance of conflicting meanings of the existing information, resulting in the vagueness of knowledge in cause and effect relationships. Thirdly, there is the inability to determine the probabilities of alternatives with any degree of assurance, in relation to the role of environment in supporting or hindering the performance of the decision unit in carrying out its function, related to this source, Lipshitz and Strauss (1997) refers to a proposal by Svenson (1992), which proposed that uncertainty in decision making is essentially the process of differentiating an alternative from its competitor, in order to convince the decision maker that it will be an advantage to implement it.

Another differentiation of sources of uncertainty that requires attention is the differentiation posited by Harwood and Stokes (2003), who focus on model formulation, and classify sources of uncertainty into the following:

1. Process stochasticity, which is a consequence of demographic and environmental stochasticity, and the apparently random behaviour of systems that have chaotic dynamics. It is sometimes referred to as natural variation or natural stochasticity.
2. Observation error, which is made up of a) measurement error, a consequence of the way in which observations are taken (e.g. the choice of sampling strategy, or errors in data collection), and b) estimation (or inference) error, which is the inaccuracy and imprecision introduced by the method of statistical inference used to estimate system parameters from observations.
3. Model error. All models are caricatures of reality and thus provide an incomplete, and potentially misleading, representation of system dynamics. Model mis-specification has two major consequences: (a) it can contribute to estimation error through the inferential process; and (b) it will induce further errors if the model is used in forecasting.
4. Implementation error. Which tries to capture the consequences of mistakes in realization of an application.

The representation of these sources of uncertainty in a model framework is showed in Figure 2.

The aforementioned differentiations of uncertainty are also captured in forestry literature, Kangas and Kangas (2004) distinguish sources of uncertainty to be differentiated as: (1) lack of information, (2) abundance of information, (3) conflicting evidence, (4) ambiguity, (5) measurement, and, (6) subjective belief. Cleaves (1994) describe different sources of uncertainty differently. These are: (1) error of measurement or error of estimation on parameter used in models, which is systematically or randomly, (2) imperfections on representing the existing fact in a system, regarding the interaction and relationship between parameters used in a model and lead to model uncertainty, (3) lack of clarity in representation of social value and preferences, (4) variability in the natural processes of elements used as parameters in model or decision making variables through time, space and social system which is a principal belief of frequency and is amenable on modeling and testing.

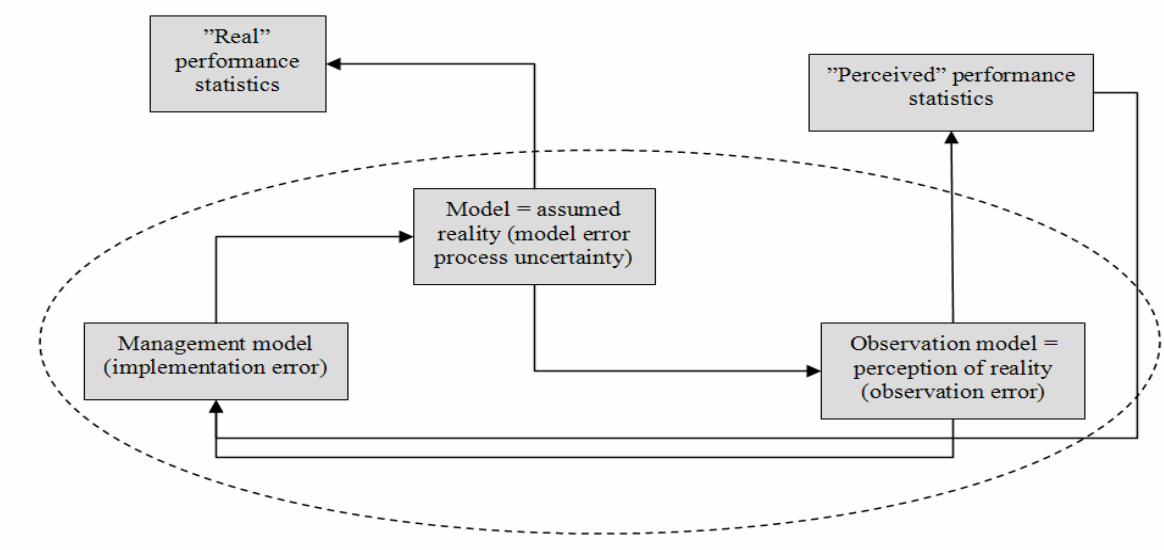

Figure 2. Interaction between sources of uncertainty (Harwood and Stokes, 2003)

In this study, differentiation of uncertainty sources by Duncan (1972), which is termed by Lipshitz and Strauss (1997) as: (1) incomplete information, (2) inadequate understanding, and (3) undifferentiated alternatives, was used. Taking this differentiation has an advantage, which is in its generalizations. It is acknowledging the lack of information problem, imperfect knowledge, and conflicting of various possible

events or circumstances in decision making, which is also implicitly expressed in the aforementioned classifications of sources of uncertainty.

2.2.2 Type of Uncertainty

Decision makers need to implement different strategy to cope with different type of uncertainty. Based on the type of information that is perceived to be lacking by decision makers, Milliken (1987) differentiates uncertainty into three different types, which focus on delineating the nature of uncertainty being experienced. These are:

1. State Uncertainty

   Uncertainty about the state of the environment means that the decision maker has no knowledge about the possible changes that can occur to the components of the environment. Decision makers experience state uncertainty when they perceive themselves as unable to predict the environment or a particular component of the environment. The lack of knowledge about the interconnection between components in the environment may also be involved in this type of uncertainty. It is appropriate that theorist who defines uncertainty as "*the inability to assign probabilities to the likelihood of future events",* try to describe an experience of state uncertainty (Milliken, 1987).

2. Effect Uncertainty

   Effect uncertainty is defined as the inability to forecast the impact of the environments future situation or changes in environment to a decision maker. The lack of knowledge on cause and effect relationships is involved in this type of uncertainty. If state uncertainty involves uncertainty about the future state of the world, then effect uncertainty involves uncertainty about the implications of a given state of events in terms of its likely impact on the decision maker ability to function in the related future state (Milliken, 1987).

3. Response Uncertainty

   Response uncertainty is defined as a deficiency of understanding on the response alternatives and/or the inability to forecast the possible consequences of a response alternative. Response uncertainty experienced by decision maker requires the need for immediate decision (Milliken, 1987). This type of uncertainty is the closest concept to uncertainty definition postulated by Conrath (1967), where he defines uncertainty as the state of a lack of knowledge about; (a) the alternatives or response options available, (b) the states of nature or outcomes likely to be connected with each and, (c) the value or utility associated with each alternative state of nature pair.

Different approaches in differentiating uncertainty carried out by Lipshitz and Strauss (1997), which is based on their differentiation of uncertainty according to their issues (the matters that decision makers are uncertain of) and sources. These are presented in the table 2. Issues taken into consideration are outcomes, situation, and alternatives, while the sources are incomplete information, inadequate understanding, and undifferentiated alternatives, which Lipshitz and Strauss (1997) termed as conflict.

Table 2 Classification System of Uncertainty Construct (Lipshitz and Strauss, 1997)

Types	Topics		
	Outcomes	Situation	Alternatives
Information			
Completely lacking	√	√	√
Partly Lacking	√	√	√
Unreliable	√	√	√
Inadequate understanding			
Owing to equivocality		√	√
Owing to instability		√	
Owing to novelty		√	√
Conflict	√		√

Authors of publications concerning uncertainty classified the type of uncertainty based on their disciplines. Surprisingly, these variants occur even within the same discipline. In forestry literature, Borchers (2005) interprets uncertainty as a knowledge problem and specified the types of uncertainty present in most decisions. There are:

- Intricate: having to process more information than one can manage or understand.
- Equivocal: having several competing or contradictory risk models or hypotheses. It requires convergence on a definition of "reality".
- Ambiguous: not having a conceptual framework, hypothesis, or risk model for interpreting information; the inability to interpret or to make sense of something.

Kangas and Kangas (2004), classified uncertainty type based on the work of Rowe (1994), who classified uncertainty is:

- Metrical: which is caused by measurement variability and uncertainty,
- Structural: uncertainty caused by the complexity of systems),
- Temporal: uncertainty about future and past state of nature and;
- Translational: uncertainty in explaining uncertain results.

Based on the fact that uncertainty type classification can be different between and within disciplines, this study considers the more general types of uncertainty as distinguished by Milliken (1987) (e.g. seen from the terms used to represent the types of uncertainty), as the most appropriate instrument to be used in order to avoid complication and biases due to specific knowledge.

2.2.3 Categories of Uncertainty

The uncertainties that decision makers face come from various aspect of the environment, such as socioeconomic, political, technological development, etc, all of which need to be conceptualize and cope differently based on these aspects. Therefore, differentiation of uncertainty takes aspects of the

environment into consideration. These need to be carried out in order to better determine appropriate strategies in coping with uncertainty, which need to be implemented by the decision makers.

Authors in various publications have considered aspects of the environment. The earliest differentiation of the environment is carried out by Dill (1958), based on the information received by a decision maker, and classifies them into: (1) task environment: this consists of aspects which are potentially relevant to goal setting and goal attainment, (2) total environment: composed of aspects with indirect influence to a decision makers behaviors. However, these classifications seem to be too broad. A more specified classification concerning the environment is suggested by Lawrence and Lorsch (1967), which is generated from an executive interview and differentiated into three important sub environments: (1) scientific sub-environment; which is characterized by relative uncertain information at any relevant time and concerns the actual condition of materials being investigated. Feedback on this sub environment can only be secured after an event has been completed, because of the rapid rate of changes in knowledge, (2) market sub environment, this sub environment perceived to be more certain due to regular and frequent feedback, and (3) technical economic sub environment, there is more certainty in this sub environment in a certain time, due to the less rapid rate of changes, since changes of process only will be approved after testing of its economic efficiency. Feedback from this sub environment is very rapid, as information on cost, quality, etc. are received on a daily basis.

Differentiation of the environment carried out by Lawrence and Lorsch (1967), was extended by several authors after their era into a more diverse number of environmental aspects, such as: (1) societal values, (2) political and legal norms, (3) economics markets and labor inputs, (4) informational and technological, and (5) physical geography and natural resources (Priem et al, 2002).

In this study, these aspects of the internal and external environment or so-called sub environment will be termed as "categories of uncertainty". This is defined as "the aspect of environment where uncertainty is experienced". The term "categories of uncertainty" is used to avoid confusion due to the usage of the term "environmental uncertainty" which been used to describe both the state of the environment and the state of the decision maker who perceived themselves to be doubt about environment (Milliken, 1987).

With respect to the categories of uncertainty in forest literature, Kangas and Kangas (2004) classify uncertainty into the categories: (1) growing stock development, (2) ecological consequences, (3) prices of forest product, (4) forest management costs, (5) general societal development, and (6) natural condition.

This research will be using categories of uncertainty determined by Price (1989), because it is considered to represent general classification of main aspects in forestry decision-making, and also acknowledging aspects considered by aforementioned researchers, they are: (1) natural environment. Most of the components of nature are beyond human control, and becomes hazardous when extreme events occurred (e.g. wind throw, cyclone, floods, etc) (2) technological advances. Development of technological advances to over come challenges occur rapidly towards an unpredictable future, and causes uncertainty in management of natural resources (e.g. veneer production machinery that processes small diameter trees, using helicopter in isolated plantation harvesting, harvesting timber in extreme elevation) (3) human behavior. The dynamics of the social aspect are unpredictable. Humans change overtime with respect to their needs, points of view, values, etc (e.g. conflicts in natural resource management, accidental forest fire, illegal logging) (4) markets, unexpected changes or surges in forest products market structures, and supply and demands could cause reformation of forest management into unpredictable paths (e.g. increasing demands on recreational area changes the focus of forest management from production to tourism, certification changes costumer preferences and demands on forest products, competing synthetic products can cause fluctuation in forest products market), and (5) policy The political environment has a strong influence in natural resource management. The course of its changes and is quite difficult to predict. This depends on present regimes that govern the nation (e.g. commitment of a country in

combating climate change in United Nation Forum on Climate Change Convention, which change the way of several aspects in forest resource management).

Research to date regarding uncertainty nearly exclusively focuses on external environment, as suggested by Duncan (1972). The internal aspects of the organizations or individual manager also contribute to decision-making that compete with time and could cause uncertainty. In recent research this potential cause of uncertainty has been relatively ignored, this ignorance might be hindering the development of theory of uncertainty (Priem et al., 2002; Duncan, 1972). Therefore, this research will also consider the internal aspects of decision-making milieu in its categories (in this case, internal aspect of forestry organization where the decision makers embedded to).

The overall dimensions of uncertainty as explained in the previous paragraphs are summarized in table 3.

Table 3. Dimensions of Uncertainty

Source	Type	Category
1. Incomplete information	1. State	1. External environment
2. Inadequate understanding	2. Effect	1.1. Natural environment
3. Undifferentiated alternatives/conflict	3. Response	1.2. Technological advances
		1.3. Human behavior (social)
		1.4. Markets
		1.5. Policy
		2. Internal (organization)

2.3 Coping with Uncertainty

Many experts from various fields carried out research on strategies to cope with uncertainty. In the field of economics for example, the problem of alternatives under uncertainty may essentially be remedied by increasing the amount of information available to the decision maker. In the organization literature, the idea of coping with uncertainty is interpreted in the understanding that organizations process information to reduce uncertainty and adapt their structure to better cope with uncertain environment. And in the strategy literature, coping uncertainty is implemented through scanning or information processing (Becker and Knudsen, 2003). These approaches essentially based on information processing.

Lipshitz and Strauss (1997) suggested increasing knowledge as a way to cope with uncertainty, and by considering argument of Smithson (1989) they proposed the following alternatives; (1) reducing ignorance by gathering adequate information and knowledge, (2) attain a maximum control or predictability and responding appropriately to the environment; and (3) in any level of reducible ignorance, uncertainty must be treated in statistical manner. They also compiled strategies to cope with uncertainty, which identified by previous researchers, and divided them into three basic strategies, which listed as follow:

1. Reducing uncertainty

   Strategies in reducing uncertainty include gathering additional information before making decision or delaying decision until additional information becomes available. In the state of no additional information being available, it is possible to use extrapolation to reduce uncertainty. Among the extrapolation strategies that can be used are; (a) statistic prediction methods resulting from current and past information; (b) assumption based reasoning, which refers to filling gaps of information by

producing assumptions. The combination of these two extrapolation strategies is called scenario building. Finally making the time horizon shorter to improve predictability can also reduce uncertainty. Generally the strategies to reduce uncertainty rely on information processing, but there is also a different approach to reduce uncertainty, i.e. by controlling the sources of variability, which decrease predictability (Lipshitz and Strauss, 1997).

2. Acknowledging Uncertainty

   Acknowledging uncertainty strategy is a second option if reducing uncertainty is considered too costly. Decision makers can acknowledge uncertainty through by taking it into account in selecting a course of action or by preparing to avoid or confront potential risks through; (a) incorporating uncertainty in concurrent alternatives evaluation, (b) choosing alternatives which are already being ranked according to the best possible consequences/risk-taking behaviour (minimax regret) or alternatives which are ranked according to the worst possible consequences/risk-avoiding behaviour (maximin strategies), (c) buffering (building gap between uncertainty and technical core) and rationing (arranging priorities based on changes post the unanticipated contingencies), (d) structural response (Lipshitz and Strauss, 1997, Price, 1989, Vercelli, 1998).

3. Suppressing uncertainty

   This last strategy includes denial (ignoring or avoiding unfavorable information) and rationalization (Lipshitz and Strauss, 1997).

Based on the different dimensions of uncertainty, decision maker respond differently, or are advised to respond differently (Milliken, 1987; Lipshitz and Strauss, 1997). According to the sources of uncertainty, the following combinations of strategies to cope with uncertainty are proposed: (1) reduction is mainly used to manage inadequate understanding, (2) assumption based-reasoning, (which means filling gaps in firm of knowledge by assumptions) is mainly used to overcome incomplete information; and (3) weighing pros and cons was used in managing conflict among alternatives. Forestalling is used as a back up strategy in all type of uncertainty, while suppression strategy was quite rare to be used as the strategy of coping (Lipshitz and Strauss, 1997). This work from Lipshitz and Strauss (1997), suggests that different strategies of coping with uncertainty are indeed need to be implemented, and they differentiate the methods to cope with uncertainties, as presented in table 4.

Another set of coping strategies that can be consider was described by Ferris (1977) in adaptive behavior deliberated through structural and procedural design. Structural response is more dedicated for organizations and not applicable to individual decision makers, since it divides the organizations responsibility into subunits in order to reduce the size and range of uncertainty faced by the organization. These sub units are meant to be a buffer between the organizational environment and the technical core, and coping with uncertainty through two functions; external representation and information processing. Additionally, the structural designed, behavior in coping with uncertainty, in organizations may also apply a variety of operating policies and procedural actions to facilitate the coping process, which also can be applied for individual decision makers. The procedural design behavior are partitioned into three groups, these are;

1. Coping by prevention; which represents coping strategies by implementing policies or procedures which will reduce the possibility of an environmental contingency to occur.
2. Coping by information; it refers to implementation of policies and procedures concerning the distribution of information to facilitate coping.
3. Coping by absorption: which represents the activities taken to internalize the effect of environmental contingencies.

From a more technical point of view, in the forestry literature, it was stated that one of the forester's strategies to cope with uncertainty is by reducing it through shortening the cutting cycle and also by implementing techniques of silviculture, tree genetics, fertilizer application and the likes. Analytical techniques have also been developed, which assist forester in considering uncertainty into decision-making. Such analytical technique is a game theory and regression analysis, which is integrated to forecast wood production and consumption. Its also considers the technological change dimension by using time series trends of wood utilization by type in different uses (Convery, 1973)

Table 4. Methods of coping with uncertainty (Lipshitz and Strauss, 1997)

Coping method	Definition
	Methods of reduction
1. Collect additional information	Conduct and active search for factual information
2. Delay action	Postpone decision-making or action taking until additional information clarifies the decision problem
3. Solicit advice	Solicit advice/opinion of experts, superiors, friends or colleagues
4. Follow SOPs, norms, etc.	Act according to formal and informal rules of conduct
5. Assumption-Based reasoning	Construct a mental model of the situation based on beliefs that are (1) constrained by (though going beyond) what is more firmly known, and (2) subject to retraction when and if they conflict with new evidence or with lines of reasoning supported by other assumptions
	Method of acknowledgement
1. Preempting	Generate specific responses to possible negative outcomes
2. Improve readiness	Develop a general capability to respond to unanticipated negative developments (e.g., put forces on the alert, leave some resources unused)
3. Avoid irreversible action	Prefer or develop reversible course of action, prepare contingencies
4. Weighing pros and cons	Choose among alternatives in terms of potential gains and losses
	Methods of suppression
1. Ignore uncertainty	Act as if under certainty
2. Rely on "intuition"	Use hunches, informed guess, etc., without sufficient justification
3. Take a gamble	"Take a chance", throw a coin, etc.

3 Research Methodology

The research methodology used in this study is presented in this chapter. Explanation regarding the research approach carried out is discussed in the first section, which followed by the explanation concerning case study selection. Section regarding data collection method is discussed by giving an overview of the selected methodology. In this section, research material selection, analysis procedure, and statistical analysis used in this study are also explained.

3.1 Research approach

In order to gain knowledge on uncertainty and its dimensions (sources of uncertainty, types of uncertainty, and categories of uncertainty) in European forestry overtime, research should be carried out respectively. Therefore, primary data should be collected from European forest management databases of a period of time. The study employs a content analysis approach, where uncertainties experienced by decision makers in forestry are assessed through their tendencies in using words to indicate uncertainty. Due to the limited amount of time in conducting this research, the study only intends to generate knowledge which is expected could contribute to further research on coping strategies with uncertainty in forestry. Therefore, this research is an exploratory study. Qualitative and quantitative analysis were carried out in order to investigate the development of uncertainty and its dimensions in forestry overtime, where the quantitative data collected from content analysis is subjected to statistical analysis.

3.2 Case study

European countries are considered to have a long history of forest management. Therefore, taking a case study in European region will be sufficient for this study, because it was European cultures that shape the early forest management, which then transferred to other regions. To gain insight on development of uncertainty and its dimensions in European forest management, one European nation should be sampled. There is a large number of European countries to choose from. However, because the researcher need to be able to interpret the uncertainty perception expressed through language, it was very essential to choose countries in the range of researcher language capability, which is English. English is United Kingdom (UK) native language and also popular in some other European countries, but because the focus of this study is professional in forestry, then it can only be done in UK. Besides, UK forestry forms and excellent case for testing uncertainty perceptions and the development of uncertainty over time, it is not a

traditional forestry country, but developments and its characteristic in forestry are typical of forestry in many European countries, for example, the high pressure of highly urbanized society in forested land, the ownership of forest area which is dominated by private owners, and most of this private owned forest area is in small holdings, upsurge in small scale forestry (Slee et a., 2005; Wiersum et al., 2005; Hoogstra and Schanz, 2008b).

3.2 Data Collection

3.2.4 Content Analysis

Content analysis is employed as a diagnostic tool for making specific inferences about some aspect of the speaker's purposive behavior (Pool, 1959): It is a research technique for making replicable and valid inferences from data to their context (Krippendorff, 2004; Weber, 1985), and also for the objective, systematic and quantitative description of the manifest content of communication (Weber, 1985; Stankey, 1972), which enable one to identify and quantify the patterns that might be representing trends or characteristics of perceptions, attitudes, and belief values of individual and/or group (Holsti, 1969; Neuman, 2005) . Content analysis is carried out in four steps: (a) selection of response categories; (b) sampling; (c) measurement; and (d) analysis (Stankey, 1972). The main concern in content analysis is categorizing words in a text into smaller or much fewer content categories. Each category could consist several or many words, which have the same or similar meaning (Weber, 1985)

In comparison with other data gathering and analysis technique, content analysis has various advantages (Krippendorff, 2004; Weber, 1985, Neuman, 2005):

1. Content analysis procedure directly works upon text or transcript of communication, which is the core of social interaction.
2. Using both quantitative and qualitative methodology in content analysis is the best study framework. Therefore, content analysis methodology combines what are usually thought to be antithetical modes of analysis.
3. Various documents existed over periods of time. Values indicated in these documents are a valuable source for reliable data generation, which may span many decades even centuries.
4. In recent times, various kinds of reliable data exist. Cultural indicators that could be generated from content analysis can be used to assess the quantitative association between socioeconomic, politic and cultural change.
5. Content analysis is an unobtrusive methodology when compared to other data generation techniques such as interview, questionnaires, experiments and projective tests. Neither the sender nor the receiver of the message is aware of being analyzed as a research object. Hence the analyst should be aware that the act of measurement itself would act as a force for change that confounds the data.
6. The absence of desirable information format does not hamper the use of content analysis to generate data, means; content analysis accepts unstructured research material.
7. Context sensitive characteristic of content analysis enable it to process symbolic forms, which may possibly be present.

Due to its advantages content analysis is used for various fields, and is commonly employed in social sciences and humanities where symbols are generally used to transacted messages (Krippendorff, 2004).

Despite all the advantages mentioned above, content analysis also has several disadvantages in both theoretical and procedural perspective (CSU, 2008):

1. It can be a very time consuming method of research.
2. Content analysis is subject to increased error, particularly when rational analysis is used to attain a higher level of interpretation. This error is the results of codification error, which will be increasing as the content analyzed is increasing in numbers.
3. It can cause difficulties when processing or analyzing, mainly due to the coding scheme that have to be integrated with automaticity or computerization.
4. It has a tendency to become a simply consist of word counts.
5. Content analysis often neglects the context that produced texts, as well as the implication after texts are produced.
6. This kind of analysis often lacks of a theoretical base, and attempts to describe meaningful assumptions concerning relationships and implication in a certain study.
7. When content analysis is applied to analyze complex text, it becomes inherently reductive.

The problem with content analysis has originated mainly from data reduction processes where the existing words should be classified into fewer categories. One major problem which arises in the process of measurement and coding, concerns consistency or reliability. This problem grows from the ambiguity of the meaning of words to the ambiguity of category definitions and other coding rules. However, classifying words into categories by using computers leads to perfect coder reliability (Weber, 1985; Krippendorff, 2004).

A large-scale sample is neither critical nor essential in this study, because this study was intended to derive some evidences from small samples and inspire futures studies. There were also criteria in selecting articles to be analyzed, which is intended to eliminate biases in uncertainty expressions (e.g. the amount of the author, range of publication year), therefore the analyzed articles was limited and the time required to carried out the content analysis method were appropriately efficient. While the employment of recent version of content analysis software (MAXQDA2), were over come the difficulties in constructing and processing the coding scheme, including its automaticity. This study was also supported by the theoretical framework, which refer to previous researches, it was intended to become a theoretical base in analyzing the context of words in representing the author perception towards uncertainty. A combination of qualitative and quantitative analysis were also carried out, in order to prevent this method to only becoming a simply words counts, besides there were also an examination of the target words context in representing (un) certainty, because words can only be interpreted with an understanding of the context in which they occur (Hyland and Milton, 1997), the examination of the words context also becoming a control in running the coding scheme, which is intended to terminate the increasing error due to coding mistakes. This study avoid considering the complex topic in forestry (e.g. forest soil structure, wood structure, tension in twisted wood) and only focus in forest management, therefore complex texts did not eminent in the selected articles. These attributes of analysis are all expected to assist in overcoming the mentioned disadvantages of this method.

Krippendorff (2004), posited that content analysis has been classified by the following:

1) Pragmatical Content Analysis – signs classification based on their probability to cause or affect a situation. (e.g., counting the number of times that something is said which is likely to have the effect of producing favorable attitudes toward Germany in a given audience).

2) Semantical Content Analysis – sign classification based on the similarity of meanings (e.g., counting the number of times that Germany is referred to, irrespective of the particular words that may be used to make the reference).
    a. Designation analysis – referring to the frequency of appearance of a certain object (subject matter analysis) (e.g., references to German foreign policy).
    b. Attribution analysis – referring to the frequency of object characterization (e.g., references to dishonesty).
    c. Assertions analysis – referring to the frequency of particular characterization of an object (thematic analysis) (e.g., references to German foreign policy as dishonest).
3) Sign-vehicle analysis – content classification based on psychophysical properties of the signs (e.g., counting the number of times the word *Germany* appears)

And the following inferences;

1. Deductive inferences are implied in their premises. For example, if all humans speak a language, then X, being human, must speak one as well. These inferences are logically inclusive, which proceed from generalization to particulars.
2. Inductive inferences are generalizations of similar kinds. For example, X might infer from the fact that all of his/her neighbors speak English that all humans do. This inference is not logically conclusive, but it has a certain probability of being correct. Statistical generalizations from smaller samples to larger populations (typical of social research) and the idea of measuring the statistical significance of scientific hypothecs involve inferences of this kind. They proceed from particulars to generalizations.
3. Abductive inferences proceed across logically distinct domain, from particulars of one kind to particulars of another kind. (These are the kinds of inferences of interest to content analysis, where they proceed from texts to the answers to the analyst's questions). Consider linguistic competence and age. Logically, neither implies the other. However, if one has practical experience with infants' language acquisition, one might be able to infer children's ages from the sounds they make or from the vocabulary the use. Of course, one can make such inferences only with a certain probability may be strengthened if one is able to take other variables (contributing conditions) into account.

This study was concerned to the authors perception on uncertainty (which then differentiated further based on its dimensions), therefore words indicating the similar perception in terms of uncertainty was grouped. And this study also supported by the predetermined key words and predetermined groups from previous researches (list of words indicating (un) certainty compiled by Hoogstra and Schanz, (2008a), differentiation of sources of uncertainty by Duncan (1972) and Lipshitz and Strauss (1997), and differentiation types of uncertainty by Milliken (1987)). These mean that semantical content analysis and deductive inferences was used in this study.

3.2.1 Content analyzed

Research material in content analysis methodology is text. Text is defined as a media for communication and is written, seen or spoken. Material included in text categories range from documents such as books, newspapers, article, work of art, speeches, etc. Content is any message that can be communicated in the form of words, meanings, pictures, ideas, themes, etc (Neuman, 2005). There are many of forest institute dedicated for forestry decision makers in the United Kingdom (UK) that publish journals. However only a few were granted with the "Royal Charter", which is a charter granted by the sovereign based on the

advice from the privy council due to the societies ability to demonstrate preeminence, stability and permanence in their particular field (Privy council, 2008, Institute of Chartered Forester, 2008). The instrument used in this research method (content analysis software), require the analyzed articles to be in electronic version. Oxford Journal of Forestry; the journal of the Institute of Chartered Forester, is a journal from the UK institute which have been granted a "Royal Charter", the publicized journals also available in electronic version and accessible from the library of Wageningen University networks. Therefore the publications from this institute were used in this study.

Articles selected for analysis are based on the following criteria:

a. Articles chosen should focus on forest management in UK
b. The authors should be native speakers
c. A single author should write the article, in order to avoid biases due to different characteristics of authors in expressing uncertainty.

Remembering there has been many changes in the last decades, for example, the debates on sustainability concepts, the emerging awareness on climate change which marked by the adoption of Kyoto Protocol in 1997, therefore this study will only consider articles which published in the last decades, which expected to capture the influence of these emerging changes on the authors perception on uncertainty. Year 1997 will be considered as the starting point, because in this year the adoption of the policy which influencing the forest management and its related aspects (e.g. biodiversity, desertification, etc) in the world has occurred (Kyoto Protocol), and because the articles which limited by the aforementioned criteria only available until 2006, therefore 2006 was used as the end point, which means the time range of publication of the selected article was 10 years (1997 – 2006) (see appendix 1).

3.2.2 Procedure of Analysis

Classifying a large number of words into categories of interest is the main idea of content analysis; therefore it requires the development of a coding scheme where a text classification system is designed to achieve particular study objectives (Bengston and Xu, 1995).

The first step in developing a coding scheme is defining the content groups, in this research it was grouped into dimensions of uncertainty (sources of uncertainty, types of uncertainty, and categories of uncertainty). Secondly, defining the basic unit of text to be classified, which are words commonly used to express (un) certainty compiled by Hoogstra and Schanz (2008a) (see appendix 2).

After the codification scheme, words frequency of appearance was analyzed, which based on the list of words commonly used to express (un) certainty by using text retrieval program MAXQDA2. The detected target words then further examined in regards to the context they represent, and determine the groups to which the words correspond to (in terms of its representation on uncertainty or certainty), because (particular) words can only be interpreted as representing (un) certainty by referring to the context in which they occur (Hyland and Milton, 1997). The contents that are categorized into expression of uncertainty then classified based on its dimensions (see table 3), with regards to its role in indicating sources, types, or categories of uncertainty. To avoid bias in (un) certainty expressions, only text from the authors themselves been considered as data to be analyzed, therefore quotation from other persons was excluded.

The results of the codification process are of a qualitative (e.g. the dimensions) and quantitative nature, and are further analyzed by statistical analysis.

3.2.3 Statistical data Analysis

The data was analyzed by using statistic analysis Software SPSS. Several statistical procedures were involved in the data analysis. Regarding the first two research questions, in relation to the development of uncertainty and its dimensions over time, several analyses was carried out. To have an overview on frequency distribution of words, cross tabulation descriptive statistic analysis was employed, where percentage of groups of words indicating certainty, uncertainty and its dimensions is presented. Further analysis to investigate the significance of differences between these groups, means comparison test was carried out. There are different types of means comparison test, which depends on the characteristic of data's distribution and amount of group to be compared. In this study, repeated one-way ANOVA and Friedman's ANOVA, which followed by Wilcoxon post hoc procedure with *Bonferroni correction* was employed.

The repeated one-way ANOVA was employed to analyze the parametric data of this study. As for Friedman's ANOVA, it was carried out to analyze the non-parametric data's, which followed by Wilcoxon post hoc procedure, in order to investigate the level of significances between paired groups of these data's. While *Bonferroni correction* was employed to overcome the possibilities of statistic Type II errors from the non-parametric data analysis.

Besides, correlation test was carried out to investigate the relationship of uncertainty and its dimensions towards time. In this study, time will be presented by article publication year. The value of correlation indicates to which degree there is a relation between two variables. This research used Pearson's correlation coefficient as it measures the strength of linear relationship between two variables. The value of Pearson's correlation ranges from -1.0 to 1.0, where -1.0 implies a perfect negative correlation, 0.0 is no correlation, and 1.0 is a perfect correlation (TexaSoft, 2007; Field, 2005).

Concerning the value of significance, the statistical significance level of 0.05 is used in this study for justification in rejecting (p-value > 0.05) or accepting (p-value < 0.05) the hypothesis. This level of statistical significance is commonly used in social research (Field, 2005).

4 Results

In this chapter the results of data analysis are presented. In the first section, an overview on expression of (un) certainty is discussed by giving the frequency of (un) certainty words used in the selected articles. The frequency of words used to express uncertainty and certainty are then investigated in order to see if there are differences between them, which indicate the condition experienced by the authors of the articles. In respect to analysis of development overtime, these expressions are examined in terms of its relation with article publication year. Regarding the analysis on dimensions of uncertainty that differentiated based on its sources, types, and categories, frequency distribution overview of each are presented in different following sections. The overview then followed up with the analysis of significances of possible differences within these dimensions. The analysis is carried out in order to know the most influencing component of dimensions of uncertainty in uncertainty expression by the authors. Finally, the correlation analysis results on dimensions of uncertainty towards time are also presented. However, as an additional analysis, test of possible difference in term of frequency of uncertainty and its dimensions expressions in each article was carried out.

4.1 Expressing (un) certainty

4.1.1. Certainty versus uncertainty

The overview on the employment of words indicating (un) certainties are presented to investigate how frequent (un) certainty are expressed by the authors of the articles. Table 5 presents the frequency of words used to indicate (un) certainty per 100 words, which showed that the authors of the selected articles employ about one (un) certainty expression every 15 words.

This figure is much higher than previous researches on the employment of words indicating (un) certainty expression. Hyland and Milton (1997) for example discovered the employment of words indicating (un) certainty in every 55 words, which is similar to those found in published academic writing: Hoogstra and Schanz (2008a) who conducted research on uncertainty expression in the forestry and agricultural sector discovered that the authors of articles in forestry employ about one (un) certainty expression every 34 words, which does not differ from the agricultural sector.

Table 5. Frequency of words used to express (un) certainty (per 100 words)

	Number of articles	Mean	Min	Max	Std. Deviation
Total of (un) certainty words	10	6.53	2.75	8.65	1.86
Uncertainty	10	3.56	1.38	6.27	1.43
Certainty	10	2.97	1.38	4.58	0.89

The high frequency of the employment of words in this research indicating (un) certainty by the authors, might be caused by the high (un) certainty concerning the factuality of their statement, or by the high level of politeness of the authors statement, because words which possibly indicate uncertainty, also pragmatically functioned as politeness markers (Hyland and Milton, 1997; Holmes 1988).

Concerning the expression of uncertainty and certainty, the number in table 5 shows that words indicating uncertainty is employed about one expression in every 28 words, and 34 words for certainty. From this figures it seems that authors of the articles expressing more uncertainty than certainty, however the one-way repeated ANOVA shows that exist has no significant differences in their frequency of appearance ($F(1, 9) = 1.376$, $p > 0.05$). Therefore it can be concluded that authors of the articles expressed the uncertainty experienced in the similar way as certainty.

An additional analysis was carried out to investigate if there is significant difference on the frequency of (un) certainty expressions between each article, which assumed to be representing each author. To carry out this analysis, Cramer's V measure was employed, and the result showed that there is significant difference (Cramer's $V = 0.192$, $p < 0.05$) on the (un) certainty expression between each article.

4.1.2 Uncertainty over time

As another concern of this research is the development of uncertainty over time, a correlation analysis was carried out to investigate whether the frequency of uncertainty expressions is correlated to time (in this study it's represented by the article publication year). Based on the correlation test, Pearson's correlation value shows that uncertainty does not have any relation with time ($r = 0.140$, $p > 0.05$), which means that the expressions of uncertainty experienced by the authors were not influenced by article publication year.

This findings are resemble with the research carried out by Hoogstra and Schanz (2008a), where their correlation test result showed that there is no correlation between the article publication year and the expressed uncertainty. As an insight, it is possible to be concluded that the trends of uncertainty experienced by the authors may not necessarily obtained by correlating it with time.

4.2. Dimensions of uncertainty

In this study, dimensions of uncertainty were differentiated based on its sources, types and categories. The overview of these dimensions are presented in this section through figures resulted by using cross tabulation, followed by the test of significances in order to investigate the possible differences within these dimensions, which also intended to know the most influencing factors in uncertainty expression by the authors. Concerning the analysis on development of dimensions of uncertainty over time, correlation analysis is carried out to investigate whether there are correlations between uncertainty expressions based on its dimension towards time.

4.2.1 Sources of uncertainty

The sources of uncertainty are differentiated into (1) incomplete information, (2) inadequate understanding, and (3) undifferentiated alternatives. The overview on frequency distribution of words indicating these sources in the articles is presented in Table 6.

Table 6. Frequency of words indicating sources of uncertainty (N = 10)

	Sources of uncertainty			
	Incomplete information	Inadequate understanding	Undifferentiated alternatives	Total
Count	116	305	32	453
Percentages	25.6%	67.3%	7.1%	100.0%

Table 6, clearly shows the differences in frequency of the three source groups, "inadequate understanding" being the most frequent source to be expressed experienced by the authors. This outcome is supported by the results from the one-way repeated ANOVA test, which indicate that there are significant differences in term of degree of influence from each sources in causing uncertainty experienced by the authors ($F(1.33, 11.93) = 69.72$, $p < 0.05$), and also supported by the findings resulted from pair wise comparison, which showed a significantly different degree of appearance of words indicating "inadequate understanding" compared to "incomplete information" and "undifferentiated alternatives". The pair wise comparison also showed a significant difference between frequency of appearance of "incomplete information" and "undifferentiated alternatives" (see appendix 3). Therefore, it can be concluded that the figures showed in table 6, also clearly represent the rank of sources of uncertainty appearance frequency.

In regards to the concern on development of "sources of uncertainty" over time, a correlation analysis was carried out. The result of this analysis is presented in table 7.

Based on the outcomes shown in table 7, none of the sources of uncertainty have correlation with the article publication year. This means that the frequency of appearance from each sources expressed by the authors were not affected by time.

Table 7. Correlation matrix fro articles publication year ad sources of uncertainty (N = 10)

		Year	Incomplete information	Inadequate understanding	Undifferentiated alternatives
YEAR	Pearson Correlation	1.000	-0.222	0.471	-0.501
	Sig. (2-tailed)		0.537	0.170	0.140

Note: YEAR = article publication year
N = number of articles

An additional analysis was carried out using Cramer's V measure, in order to investigate whether there is difference between expressions of sources of uncertainty between each article. The results from this

measure showed that, there is a significant difference in the frequency of expression in terms of sources of uncertainty between these articles (Cramer's $V = 0.272$, $p < 0.05$). Therefore it can be interpreted that, these sources of uncertainty has different degree of influence in causing uncertainty experienced by each author of the selected articles.

From these findings, briefly it can be interpreted that different degree of influences from these sources in causing uncertainty experienced by the authors, does not necessarily correlated with time, but strongly related to personal characteristics. The insight from this analysis strengthens the theory of uncertainty in terms of personal perceptions.

4.2.2 Types of uncertainty

In this study type of uncertainty was differentiated into (1) state uncertainty, (2) effect uncertainty, and (3) response uncertainty. Despite of this differentiation, another category of type was added due to the incomplete information to define the related context of words, which is termed as nothing. The overview of frequency distribution of these types is presented in table 8.

Table 8. Frequency of appearance of words indicating types of uncertainty

	Types of uncertainty				
	State	Effect	Response	Nothing	Total
Count	223	141	88	1	453
Percentages	49.2%	31.1%	19.4%	.2%	100.0%

Note: Nothing = words indicating uncertainty that cannot be identified to be one of the three types.

Referring to the results as presented in table 8, it shows that authors of articles were experiencing distinctive degree of different types of uncertainty, which seems dominated by state uncertainty. The Friedman's ANOVA test results with Bonferroni correction showed that indeed the authors of the selected articles experiencing significantly different degree of various types of uncertainty (X^2 (3) = 22.12, $p < 0.05$). This test is followed up by Wilcoxon post hoc test which is also corrected by Bonferroni correction, and indicates that the significant difference actually only occur to the appearance of state uncertainty ($p < 0.05$), while "effect" and "response" uncertainty is similar to each other ($p > 0.05$) (see appendix 4). Referring to the rank of means of these types, which strengthen by the value of significance as mentioned before, state uncertainty was certainly the most frequent type of uncertainty experienced by the authors (see appendix 5).

As for the type of nothing, this type is the least frequent to be occurred and significantly different in terms of degree of appearance with any other types of uncertainty. However, the appearance of these words needs to be anticipated in future studies and is defined with more rigorous criteria of in defining uncertainty types.

Referring to the various analyses carried out to the types of uncertainty, correlation test was employed to investigate the possible relationship between types of uncertainty experienced by the authors and development over time. The result of this test is presented in table 9.

Table 9. Correlation matrix for article publication year and types of uncertainty (N = 10)

		Year	State	Effect	Response	Nothing
Year	Pearson Correlation	1.000	0.131	-0.119	0.019	-0.290
	Sig. (2-tailed)		0.719	0.744	0.959	0.416

Note: Year = article publication year

N = number of articles

The figures on table 9 indicate that there are no significant correlations in regards to the types of uncertainty experienced by the authors, and article publication year. This correlation test results showed that the authors perceived decision-making circumstances were not influenced by time.

Additionally, the differences in frequency of types of uncertainty expression between each article was analyzed by Cramer's' V measure, where the results indicate that there are different pattern of domination from these types of uncertainty in each article (Cramer's $V = 0.265$, $p < 0.05$). Referring to these results, it can be concluded that author of each article experiencing different domination of types of uncertainty.

4.2.3 Categories of uncertainty

A similar analysis as carried out for the two dimensions of uncertainty was carried out for categories of uncertainty. Table 10 presents the overview of frequency distribution of categories of uncertainty in the articles. Despite the differentiation of the existing categories of uncertainty, additional category need to be added due to the incomplete information to define the context of words indicating uncertainty, and grouped these words into category of "nothing".

Table 10. Frequency of words indicating categories of uncertainty

	Nat	Tech	Hmn	Mrkt	Pol	Org	Not	Total
Count	215	117	27	40	12	39	3	453
Percentages	47.5%	25.8%	6.0%	8.8%	2.6%	8.6%	0.7%	100.0%

Note : Nat = natural environment Tech = technological advances

Hmn = human behaviors Mrkt = market

Pol = policy Org = internal organization

Not = words indicating uncertainty that cannot be identified to be one of the six category

The results presented in table 10 shows that author of the selected articles experiencing different degree of uncertainty, in terms of domain of the decision-making environment. Overall, this overview indicates that these authors express uncertainty about natural environment much more frequently than any other categories. The second most frequent mentioned category of uncertainty is the technological advances group. The rest of the categories were not frequently expressed, especially when compared to the two previous categories.

To investigate these variations of frequency of appearance, further analyses were carried out. The results from Friedman's ANOVA test with Bonferroni correction indicate that, there are significant differences in the frequency of appearance of words indicating these categories of uncertainty (X^2 (6) = 31.725, $p < 0.05$). To understand the exact differences between these categories, Wilcoxon post hoc test was employed, which is also corrected by the Bonferroni correction. Based on the results of this analysis, categories of uncertainty that are significantly frequent in term of degree of appearance in the articles were natural environment and technological advances ($p < 0.05$), while the rest of the categories, have various degree of significances in terms of appearance between each other. In other words, some of these categories were significantly different with each other, while others were similar., e.g. category of uncertainty concerning human behavior is similar with market, policy, and internal organization ($p > 0.05$), while market and policy is significantly different with each other ($p < 0.05$) (see appendix 6).

The non parametric two related sample test with Bonferroni correction were carried out to proven the exact differences between these groups, which indicated by the ranks of means in terms of frequency of appearance resulted from Friedman's ANOVA test. And referring to these ranks, uncertainty about natural environment is the first rank, and followed by technological advance as the second. As for the rest of the categories but category of nothing, has means that range from 3.05 to 3.90 (see appendix 7)

Finally, as carried out to other component of dimensions of uncertainty, correlation test consequently carried out to categories of uncertainty, in order to investigate its development over time. Figures of the correlation result are presented in table 11.

The correlation test results presented in table 11 showed that there is correlation between the categories of natural environment, market, and internal organization with article publication year ($p < 0.05$). While the categories of technological advances, human behaviors, policy, and nothing, has no correlation with article publication year ($p > 0.05$), which means uncertainties regarding these categories were not influenced by time.

Table 11. Correlation matrix for article publication year and categories of uncertainty (N = 10)

		Year	Nat	Tech	Hmn	Mrkt	Pol	Org	Not
Year	Pearson Correlation	1.000	0.869**	-0.201	-0.402	-0.784**	-0.247	-0.676*	-0.437
	Sig. (2-tailed)		0.001	0.577	0.249	0.007	0.492	0.032	0.206

Note: **. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).
Year = article publication year Nat = natural environment
Tech = technological advances Hmn = human behaviors
Mrkt = market Pol = policy
Org = internal organization
Not = words indicating uncertainty that cannot be identified to be one of the six category.

Based on the characteristic of the existing correlation, natural environment has a positive relation with time, which means that the older the articles, the more certain the authors were towards natural environment. As for category of market and internal organization, their negative correlation with time indicate that the more recent the article, the more certain the authors were on market and internal organization.

Overall, it can be concluded that changes related to time do not have influence to authors' perception on uncertainty about technological advances, human behaviors, and policy, while the contradictory is the case for the natural environment, market, and the internal organization.

However, another analysis was carried out, concerning the differences in frequency of categories of uncertainty expression between each article using Cramer's' V measure, where the results indicate that there are different pattern of domination from these categories of uncertainty in each article (Cramer's V = 0.333, $p < 0.05$). Referring to these results, it can be concluded that author of each article experiencing different domination of categories of uncertainty

4.3 Overview of the main results

On basis of the main outcome, it can be concluded that the authors of the articles selected for this study express uncertainty in the similar way with certainty, in a very frequent rate compared to previous researches on uncertainty expressions (e.g Hyland and Milton, 1997; Holmes, 1988; Hoogstra and Schanz, 2008a). However, the uncertainty development was not correlated with time.

Concerning the dimensions of uncertainty (sources, types, and categories), it appears that the most influencing source of uncertainty experienced by the authors is "inadequate understanding". This was very constant over time. Regarding the types of uncertainty, state uncertainty is the most frequent type experienced by the authors, while "effect" and "response" uncertainty were expressed in the similar rate with each other. None of these types demonstrated any change over time. The last dimension of uncertainty was concerned to "categories of uncertainty". Uncertainty about the natural environment is the most frequent category of uncertainty, which is followed by technological advances. However categories of uncertainty that has correlation towards article publication year were uncertainty about natural environment, market, and internal organization, where the first was having a positive correlation and the others were negative. Positive correlation means that the older the articles, the more certain the perception of its authors, and contrary for the negative correlation.

5 Discussion

In this chapter, findings of this study regarding the development and correlation of uncertainty and its dimension in forestry towards time will be discussed. Consequently, the discussion also will be accompanied by plausible explanations of the findings. Concerning the consequences of the findings towards decision-making in forestry, it will be followed up in the discussion of the section after. The identification of limitation existed in this study and recommendations for further research are presented in the last section of this chapter.

5.1 Development of uncertainty and its correlation with time.

This research did not find significant differences between certainty and uncertainty, which mean that the level of uncertainty condition experienced by decision makers in forestry, are similar to certainty condition. These findings comply with the work of Hoogstra and Schanz (2008a) in forestry literature, who found that there is no significant difference between the average number of words used to express uncertainty and certainty in forestry publications.

However, compared to the results of previous researches on uncertainty expressions, words commonly used to express uncertainty were frequently found in the articles of this study. These findings could be interpreted that decision makers in this study were facing a high level of uncertainty.

In the original analysis of this study, a significant difference was identified in the frequency of words indicating uncertainty between the articles, which could be interpreted that authors of the articles were experiencing a different degree of uncertainty between each other or, they perceived uncertainty differently. This finding gives an insight to the link between uncertainty expression and individual characteristic. Perception of uncertainty is a personal characteristic; decision makers in the same setting may experience different level of uncertainty. An individual might perceive a specific situation as fully known and certain, in the same time, another individual may perceive it as not fully known and experiencing uncertain situation. This concept also occurred to the strategy to cope with uncertainty, where different individual might implement different strategy to cope with equal situation that perceived as uncertain. For example, individual who perceive the uncertainty of the future as threat, may try to ignore it and pretend that the future will be as the same as the present. In contrast, individual who perceive it as an opportunity, may even see it a chance for entrepreneurship. However, in term of collectivity, perceiving and coping with uncertainty is more than personal variable, there is a differentiation between the person in representing himself and the person as a representation of the

collectivity. Every collective has created their own culture as a guideline to express signs, communication, rituals and behaviors of its member. Forestry can be interpreted as a social collectivity with its own culture, which can be used as a guideline for decision-making (Hoogstra and Schanz, 2008a; Conrath, 1967). Therefore, authors of the articles are assumed to perceive uncertainty as the same, because they are from the same social collectivity in term of forestry and nation.

A further analysis on the findings of this study was carried out in relation with time. The correlation test results between uncertainty expression and time, where in this study it was indicated by the article publication year, showed that there is no significant correlation between them, which means the frequency of uncertainty expression might be not influenced by time, these findings also found in the work of Hoogstra and Schanz (2008a). Therefore, it is possible to conclude that the trends of uncertainty experienced by the authors may not necessarily obtain by correlating it with time.

Referring to the significant differences between uncertainty expression between each articles, and the correlation test result between uncertainty and article publication year, it is possible to say that the influence of personal characteristic (age, education, organization, gender, etc) is much more important than time. These personal characteristic shapes the perception of an individual in perceiving the uncertainty they experienced. As an example is the different degree of uncertainty experienced by different individual from different organization, as stated by Hofstede (2001) that different organizations have adapted to uncertainty in different ways, they develop the mechanism of decision-making rules to cope with uncertainty based on their experiences (Hofstede, 2001). Therefore, the differences on frequency of uncertainty expressions between each articles is reasonable, because even though the authors are in the forestry sector which share a guideline to express uncertainty, they have different personal characteristics.

5.2 Dynamics of uncertainty dimensions over time

5.2.1 Sources of uncertainty

Results concerning the analysis of sources of uncertainty showed that the three sources have significant differences between each other, in terms of their degree of influences towards uncertainty experienced by the authors. Where "inadequate understanding" was discovered to be the most frequent source of uncertainty to be occurred, compared to "incomplete information" and "undifferentiated alternatives. This result is resemble with the work of Lipshitz and Strauss (1997), who found "inadequate understanding" as the most influencing source in causing the uncertainty experienced by decision makers.

Based on the findings from the research carried out by Lipshitz and Strauss (1997), the following reasoning's are possible. Even though the lack of information is the most common reasoning used by researchers as the cause of uncertainty, decisions makers are sometime faced with uncertainty not because they are lack of information, but because they are overwhelmed by the abundance of conflicting meanings of these information's. As they try to identify a particular situation and find the absence of one to one correspondence causing this situation, then as rationality failed to explain this relation, decision makers experience inadequate understanding. This condition is commonly coped by using the strategy of reduction. As another scenario that might be happened is, the additional information needed to identify a particular situation is not available, in this sense, decision makers experience incomplete information. Responding to this condition, they implement the assumption-based reasoning strategy in order to cope the uncertain situation cause by it. If in the process of identifying the particular situation decision makers generate several reasonable options, then they experiencing undifferentiated alternatives, or so called conflict. The commonly used strategy to cope with the uncertain condition caused by this source of uncertainty is by weighing pros and cons.

Consequently, based on the correlation test results between sources of uncertainty and time, it can be concluded that incomplete information, inadequate understanding, and undifferentiated alternatives were not influenced by article publication year. Therefore it can be concluded that degree of uncertainties experienced by decision makers in forestry, may not necessarily dependent on time. This insight might support the definition of uncertainty of being the characteristic of an individual, its degree of occurrence is strongly influenced by his or her own perception of the decision making environment, despite of the real dynamic changes of the environment that related to time.

5.2.2 Types of uncertainty

Findings regarding the types of uncertainty in this study showed that, the most frequent type of uncertainty being experienced by the authors is "state uncertainty", which is significantly more frequent then "effect" and "response" uncertainty. In respect to the "effect" and "response" uncertainty, they were experienced the similar rate with each other.

The type of information that perceived to be lacking differentiates these three types of uncertainty. Milliken (1987) explained these differentiations in his works; where state uncertainty is related to the lack of information on the nature of the environment. While effect uncertainty experience does not necessarily caused by the lack of information, decision makers may possibly have the information needed or that possibly handle to, but the shortage of proper knowledge concerning the changes or sets of changes that might be affecting the organization is the main consideration. As for response uncertainty, it's more related to the lack of information on the alternatives of responses available to decision makers, and/or the utility of course of action to achieve the desired outcomes.

The uncertainties experienced by the forestry decision makers may possibly change they behavior towards decision-making. The inability to know or predict the nature of environmental changes, which is faced by decision makers experiencing state uncertainty, may lead to the difficulties in identifying opportunities and threats in any degree of confidence, where in the end will cause the decision making strategy of the decision makers resemble with non linear strategic thinking (decision made based on randomization of possible choices) (Milliken, 1987). Decision makers who experienced a high degree of state uncertainty and see them as a threat, may resist changes in their decision making environment in order to secure them self (Asare et al., 2006). While decision makers who see the uncertainty of the future state as full of opportunities, will acknowledge these changes and even see it as a chance for entrepreneurship (Hoogstra and Schanz, 2008a).

The coping strategy particularly implemented by decision makers who experienced state uncertainty mainly involved scanning and forecasting. Where scanning is purposed to identify the trends, changes, and events that possibly affecting them, and forecasting is for predicting the possible trends of these changes. As another alternatives is by acknowledging the state uncertainty, through selecting a course of action and by preparing to avoid or confront the potential risks (Milliken, 1987; Lipshitz and Strauss, 1997).

As for effect uncertainty, it is much more related to the inability to understand the consequences of changes in the environment toward individual and/or organization. This type of uncertainty might occur in the phase of identification of threats and opportunities in the planning process. In this sense, decision makers will spend most of their time and resources in the phase of analyzing the environmental threats and opportunities, which in the end require them to judge the tendency of an environmental change in affecting themselves. Formulation of contingency plans is one response that possibly proceeded by decision makers experiencing this type of uncertainty. The last type of uncertainty experienced by decision makers is the response uncertainty; this type of uncertainty is occurred as they try to understand the range of possible responses and their utility towards environmental changes. As for this type of uncertainty, decision makers might carry out alternatives of actions. For example, they might be delaying their strategic

planning, in the case of high degree of response uncertainty; they might imitate the strategic responses of others (Milliken 1987; 1990).

However, the findings of this study resemble to those of Ondersteijn et al. (2006). In their work, they discover that state uncertainty was the most frequent type of uncertainty experienced by the decision makers, and response uncertainty was the least frequent. This result indicate that even though the decision makers were very uncertain about the nature of changes in decision making environment, they are more certain about the alternative strategies to over come these changes. Ondersteijn et al. (2006) also discovered the similar degree of effect and response uncertainty experienced by the decision makers. This finding may be interpreted that decision makers have a certain degree of control towards changes that might occur to decision-making environment. Because it seems to be that they have alternative strategies to over come almost all of the effect from changes of decision-making environment, therefore they experienced the similar rate of effect and response uncertainty.

A further discussion concerning types of uncertainty is concerning its development over time. Figures from correlation test indicate that the types of uncertainty are stables over time. This result could be means that the degree of uncertainties that experienced by the decision makers, in terms of its types, were not influenced by time. In other words, the uncertainty of possible changes in decision making environment, effect of the changes and alternative strategies to over come these changes were not determined by the time of the occurrence of the changes. By referring to the significant differences between the selected articles, the degree of types of uncertainty might be more determined by decision maker personal background. This insight may imply to the difficulties in defining trends of the circumstances (state, type, and response) that possibly occurred for decision-making in forestry, in terms of its correlation with time.

5.2.3 Categories of uncertainty

This study also analyzed the dynamics of the categories of uncertainty. The outcomes show that the natural environment was the most prominent categories of uncertainty. Natural environment of the forest is subject to many different disturbances (e.g. forest fire, storms, beetle, drought, climate), mostly because of the fluctuations in the physico-chemical environment, and also changes coming from biotic factors in the ambient milieu However, an eminent point of view in forest management is that forests possess an innate tendency to recover themselves to equilibrium, despite of the disturbance type. Consequently, this point of view followed by the perception that forests are able to providing stable productivity over time (Bodin and Wiman, 2007). Besides, culture in forestry has a doctrine of long run horizon, where the nature perceived to moves and changes slowly, and take a long time to accomplish such purposes as growing timber. In adapting to this doctrine, forestry decision makers need to look to the past, and perceived the future will be like the past, and should be like the past (Duerr, 1979). These points of view might be the results of learning from past experiences, but some events were very rare to occur. Events that might occur with the probability less than 1 percent of the time, will be very difficult to asses, because few people have had any experience with such events or outcomes, therefore it can cause great changes that never been imagined before. (Cleaves, 1994). As an example of this kind of events is what has been emerging in the last decades, which is the occurrence of climate change. Bodin and Wiman (2007) highlight an increase in extreme events through out Europe caused by the changing climate, e.g. the 2005 storm "Gudrun" that caused large scale direct damages to Swedish forest where about 75 million m^3 of forest were wind-felled, the 2003 summer heat and drought that cause productivity reduction, and a function shift to carbon source, over much of Europe, and the occurrence of forest fire which is not considered as a serious problem in the past, has been resulting an exceptionally high number of fires, and the area burned in the last decades.

Therefore the point of view of forest being stable might be a mirage, or the accuracy of this point of view only valid to some extent of disturbances, in terms of their number, scale, frequency, etc. In this sense, the high degree of uncertainty experienced by the decision makers discovered in this study is reasonable, because their production processes which is very dependent on natural environment (e.g. growing timber) and take a long period to be accomplished, might be suffered losses due to the aforementioned disturbances, more over it is escalated by the occurrence of climate change.

Technological advances in this study were interpreted to be not only consisting of hardware and software, but also includes practical application of knowledge, e.g. wind throw prediction models. Uncertainties concerning technological advances were also frequently mentioned. Technology tends to develop in a rapid rate, its development usually lean to the production of new competing products and causing the instability of demands, because of the uncertainties and difficulties in substitution problem, forecast in forest management tend to assume it away (Convery, 1973). The uncertainties raised concerning the development of technological advances in the future might escalate the insecurity of decision-making on natural resources, remembering that some of natural resources characterized by the irreversibility in terms of its quality (Beltratti, et al., 1998), , e.g. possibilities of desertification in tropical forest due to over logging which might caused by the development of advanced technology in harvesting timber in difficult areas. In regards to the model formulation, errors concerning its representability of the environment conditions, and its implementation also might lead to the high degree of uncertainty, because models are basically the effort to simplify the complex environment. According to theorist, much of the uncertainty that related to a complex system is intrinsically irreducible by science (Borchers, 2005).

A theory that might be appropriate to be considered in regards to these findings (high degree of natural environment uncertainty which is followed by the high degree of technological advances), is a theory proposed by Hofstede (2001), who argue that technology was developed to over come the uncertainty about natural environment. Therefore, there is a possibility that the high degree of technological advances uncertainty, caused by the high degree of natural environment uncertainty.

As for category of human behavior, the uncertainty degree concerning human behavior was not significantly different with the rest of the categories, but natural environment and technological advances. The similar rate of uncertainty experienced by the decision makers regarding human behavior, might be caused by the influence of personal characteristic towards market, policy, and internal organization.

Another concern regarding categories of uncertainty is related to market. The uncertainty about market was experienced in the same rate as uncertainty concerning human behavior and internal organization, but significantly different with uncertainty about natural environment, technological advances, and policy. These differences also applied to the category of internal organization.

Despite of their level of differences, these categories of uncertainty (human behaviors, market, policy, and internal organization), were less experienced by decision makers compared to uncertainty about natural environment and technological advances. This might be related to the ability of an individual to control these categories, for example, law and regulation was compiled to control human behavior, institution such as WTO (World Trade Organization) was created to regulate trades and market, policy was made based on human point of view, organization has procedure to operates, etc.

Finally, based on the findings in regards to the correlation of uncertainty categories towards time, it is demonstrated a significant correlation of natural environment, market, and internal organizations, over time, while other categories were not influenced by time. Trends that emerging in the natural resources decision makers nowadays, including forestry, is climate change. This might be a factor in escalation of uncertainty expression in relation with time. It is believed that climate change is an event that possibly escalate the occurrences of extreme events, in terms of their frequency, scale, number, etc, which has great consequences, such as forest fires, wind throw, insects and pathogens, forest growth, etc, remembering

climate is a very important element in natural environment. Moreover most of the science community agrees that even with drastic mitigation measures taken, the troposphere temperature is rising and will continue to do so (Bodin and Wiman, 2007). The negative relationship between time and uncertainty about market, means that the older the article the more uncertain the authors about market. This correlation might be caused by the absence of institutions, and/or regulation in the past that regulate trades in forest products, therefore the ability to control the market was quite difficult, compared to these days. The same correlation characteristic between internal organization and time possibly appear due to the adaptation ability of the organization to cope with uncertainty, as time goes organization learn from their experiences and attempt to immunize their technical core from environmental contingencies through structural and procedural design (Ferris, 1977).

Overall, the representations on time series were not ideal in this study due to the limitation on material availability, even though it was sufficient for exploratory study. Therefore, the conclusion derived from this study remains tentative due to the absent of rigorous testing by using large samples and overcoming the existing shortcomings. Even though limited by material availability, the findings of this study provide an insight into the link between uncertainty expression and individual characteristic. It is demonstrated that the intensity of uncertainty expression between articles has significant differences, which means that authors of the articles selected for this study could be experiencing different level of uncertainty or perceived them differently. Perceiving uncertainty in forestry is not only an individual variable: there is a differentiation whether the individual representing his own self or the collectivity. In this sense, the authors are assumed to be having the similar perception of uncertainty between each other, because they are in the same social collectivity in relation to forestry and nation, with a culture that created as a guideline to express signs, communication, rituals and behaviors of its member.

5.3 Dimensions of uncertainty and coping strategies

In order to answer the last question of this research, the analysis should refer to the theory postulated by Milliken (1987), who stated that decision maker need to implement different strategy to cope with different uncertainty. Even more by considering the limitation of time and resources possessed by the decision maker, it is necessary to effectively and efficiently allocate them to cope with uncertainty. Referring to the findings of this study, it was indicated that the uncertainties experienced by the decision makers, were indeed showing differences in terms of its dimensions and degree.

Based on the most frequent uncertainties experienced by the decision makers concerning its dimensions in this study, in order to cope with uncertainty caused by inadequate understanding, consequently they were required to gather additional information, if this was not possible, then they have to use the extrapolation strategies, either by statistic prediction or filling gaps of information by generating assumption (assumption based reasoning). It is also possible to be combined these extrapolation strategies, which then called as scenario building. Additionally, to cope with state uncertainty, decision makers have to allocate most of their time and resources for scanning and forecasting. While the uncertainty concerning the natural environment, might be better cope by increasing awareness on the sustainability of natural resource management.

However, careful interpretation of the results from this study is required. The conclusions discussed in this study are based only on the text analysis and did not measure the perception of uncertainty nor authors' response to cope with uncertainty. Instead, it focused on uncertainty expression that communicated through verbal communication, which considered being the outcome of authors' perceptions and matching strategy. Because uncertainty expression is attached to culture, this approach was considered to be appropriate in providing excellent ways to rationalize cultural patterns of groups, institutions, or societies (Weber, 1985). However, the application of various approaches is important to gain more understanding on uncertainty experienced in forestry. In other words, to increase the validation

and reliability of this study, empirical evidence in terms of uncertainty perception and coping strategy on actual society of forestry decision-making needs to be produced. By combination of these approaches, decision makers are expected to develop strategies to better cope with uncertainty.

5.4 Limitations and suggestions for further research

There are several limitations in this study. As the aim of this study was to analyze the development of uncertainty and its dimensions (sources, types, and categories of uncertainty), and their development over time, it would be ideal to involve large samples with a wider time span to test the development of uncertainty and its dimensions. Therefore, the main concern is that the range of time span of the article does not necessarily represent the long time period due to the limited sample. In regards to the expression of uncertainty as a personal characteristic, it will be perfect if the study only consider articles from the same author for a certain period of time, because then the uncertainty expressed by the authors will be purely representing the development of uncertainty over time, and eliminating the author background factor that influencing the degree of uncertainty expressed. However, due to the limitation of material and time, this study was selecting articles from different authors in a period of time. As a social collectivity, forestry has created their own culture which used as a tool for communication, rituals and behaviors of its member (Hoogstra and Schanz, 2008a; Conrath, 1967), therefore uncertainty expression which is attached to personal characteristic and different between individuals, may not pose serious problem.

In terms of its representativeness in explaining uncertainty in European forest management, this study may not representing the forest management with high degree of representativeness, because it was only consider forestry in United Kingdom (UK). However, firstly, this study was an exploratory study, which is intended to derive some knowledge concerning development of uncertainty and its dimensions in European forest management; therefore, a large sample was not necessarily required, in terms of region coverage, besides, UK has more or less similar trends in forestry management as in any other European countries. Secondly, the researcher need to understand the material collected for this study, however, because the researcher has limitation on language capability, which is limited to English, and UK is the only European region that is English native. However, to increase the representativeness from this kind of study, the sample size in terms of regions coverage need to be increased.

Despite of the limitations, this exploratory study did derive some valuable points and suggestions for further research. First, a potentially important contribution from this study is the importance of differentiating uncertainty based on its sources, types, and categories (dimensions of uncertainty). It has been proven that the decision makers experienced these dimensions of uncertainty with different degrees; therefore they need to implement different strategy to cope with it. Second, this exploratory study also could stimulate a more precise differentiation in uncertainty dimensions, in order to avoid the existence of unrecognized groups of uncertainty expressions.

This is the first time uncertainty differentiation approach was carried out in forestry research. There are still a number of issues that has not been examined yet due to the time restraint in this study. Further research on this issue is suggested to focus on the interaction between dimensions of uncertainty, because all dimensions of uncertainty was experienced by each author, the higher degree of uncertainty of one dimensions than the others might be caused by the higher degree of certainty in other dimensions, and vice versa. Concerning uncertainty as personal characteristic, this study did not investigate the influence of personal characteristics (education, organization, age, gender, etc) towards uncertainty expressions, remembering the findings in this study indicate that even though most of the differentiations were not correlated with time, and the authors considered is in the same social collectivity (forest sector and nation), the significant differences between each articles still exist, therefore, further research on this matter is suggested, in order to know the most influencing personal characteristic in perceiving uncertainty. This study also did not differentiate the internal organization into divisions that form the

organization itself, but compound them into one category of uncertainty. By considering that organization is formed from various divisions with different task and different degree of importance, moreover in terms of their influence in determining the uncertainty which being experienced, further investigation concerning these issues is wished.

6 Conclusions

Studies concerning development of uncertainty based on its dimensions (sources, types, and categories), and its development with time in the forestry sector have not been carried out so far. As a potential role in contributing to the development of strategies for coping with uncertainty in forestry, this exploratory study has attempted to explore the development of uncertainty and its dimensions over time. The following conclusions were derived from the analysis of data produced from this study.

No significant differences were found in the expression of uncertainty and certainty, which means that decision makers perceived these experiences as similar to each other. And regarding its correlations with time, the findings from this study indicate that there the certainty and uncertainty development was not correlated with time, and could be interpreted that the uncertainty experienced by the decision makers were not influenced by time. Resemble with previous research (e.g. Hoogstra and Schanz, 2008a), it can be concluded that the forestry sector that characterized by the long time horizon of production does not necessarily experienced a higher uncertain condition compared to its certain condition.

The findings from this study also concerning about the development of dimensions of uncertainty (sources, types, and categories) overtime. First, in regards to the sources of uncertainty, each of these sources has significantly different influence towards the uncertainty experienced by the decision makers. And the most influencing source was "inadequate understanding", therefore it can be concluded that even though "incomplete information" was the most frequently cited source of uncertainty, the lack of knowledge (inadequate understanding) regarding the existing information's and the interaction between these information's, may lead to a high degree of uncertainty. In regards to the correlation between sources of uncertainty and article publication year, the findings of this study showed that there are no correlation between them. In other words, the development of sources of uncertainty may not necessarily influence by time.

Decision makers in this study also experiencing different types of uncertainty, and the most frequent type being experienced was "state uncertainty", while the least was "response uncertainty", which means that even though decision makers were uncertain about the development of their decision making environment, they were more certain about the strategy choices to cope with it. While "effect uncertainty" was experienced in the similar rate with "response uncertainty", this might be interpreted that to some extent, decision makers have a certain degree of control towards changes that might occur to decision-making environment. As for the correlation between types of uncertainty and article publication year in

this study, no correlations were found between them. This might imply to the conclusion that development of types of uncertainty, does not necessarily determined by time.

Concerning the categories of uncertainty, the results derived from this study showed that uncertainty about "natural environment" was the most frequent uncertainty experienced by the decision makers. Natural environment are naturally a subject to inevitable disturbances, and many of this changes are irreversible, unpredictable, and has a great effect not only to the current generation, but also to the future generations. However, this high degree of uncertainty might also possibly caused by the emerging changes in climate, which escalate the intensity, frequency, and number of extreme events to be occurred. Analysis results from this study concerning correlation between categories of uncertainty and article publication year, showed that only "natural environment", "market", and "internal organization" which has correlation with article publication year, however, positive correlation only occurred to natural environment. Which means that the older the article, the less uncertainty expression existed in the article.

Regarding the last research question, the findings in this study indicate the importance to differentiate uncertainty into dimensions of uncertainty, which possibly based on its sources, types, and categories. The urgency of these differentiations was because different problems need to be coped by different strategies. In order to develop strategies to better cope with uncertainties, decision makers need to consider these differentiations. As proposed by the previous studies, uncertainty caused by "inadequate understanding" was primarily coped by reducing strategy, and "state uncertainty" may require decision maker to use their time and resources for scanning and forecasting, while the uncertainty about nature obliged the decision makers to increase awareness on sustainability in natural resources management.

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APPENDIXES

Appendix 1. List of articles analyzed

Journal of the Institute of Chartered Forester

1. Thurkettle., V. 1997. The Marketing of British Hardwood. In: Institute of Chartered Foresters, 70 (4), 319 – 325.
2. Price, C., 1997. A Critical Note on a Long Running Debate in Forest Economics. In: Institute of Chartered Foresters, 70 (4), 389 – 397.
3. Lucas, O. W. R., 1997. Aesthetic Considerations in British Forestry. In: Institute of Chartered Foresters, 70 (4), 343 – 349.
4. Cannell, M. G. R., 1999. Growing Trees to Sequester Carbon. in UK: Answers to some Common Questions. In: Institute of Chartered Foresters, 72 (3), 237 – 247.
5. Kerr, G., 2000. The Potential for Sustainable Management of semi-natural Woodlands in Southern England using uneven-aged Silviculture. In: Institute of Chartered Foresters, 73 (3), 227 – 243.
6. Quine, C. P., 2000. Estimation of Mean Wind Climate and Probability of Strong Winds Risk Assessment. In: Institute of Chartered Foresters, 73 (3), 247 – 258.
7. Grayson, A. J., 2002. Progress Towards Continuous Cover Woodland: Ipsden State. In: Institute of Chartered Foresters, 75 (3) 257 – 271.
8. Mason, W. L., 2002. Are Irregular Stands more Wind firm?. In: Institute of Chartered Foresters, 75 (4), 347 – 355.
9. McIntosh, B., 2006. Native Pinewoods in Scotland: Perspectives on Policy and Management. In: Institute of Chartered Foresters, 79 (3), 303 – 307.
10. Humphrey, J. W., 2006. Ecology and Management of Native Pinewoods: Overview of Special Issue. In: Institute of Chartered Foresters, 79 (3), 245 -247.

Appendix 2. List of English expressions

(be) bound to	can't/cannot	could (n't/not)	have (got) to
may (not)	might (not)	must	ought to
should (n't/not)	will (not)	would (n't/not)	will not/won't
appear	argue	assume	assure
believe	bet	claim	consider
convince	(not) doubt	ensure	estimate
expect	feel	guess	hope
imagine	indicate	(not) know	look as if
look (like)	predict	presume	reckon
seem	speculate	suggest	suppose
tend	think	threaten	
about	actually	almost	always
apparently	approximately	around	at first sight
beyond doubt	certainly	clearly	commonly
definitely	doubtless	essentially	evidently
in reality	generally	hopefully	in fact
frequently	in theory	in X's opinion	in X's view
indeed	indubitably	inevitably	largely
likely	maybe	naturally	necessarily
never	normally	obviously	of course
often	perhaps	plainly	quite
presumably	probably	(un) questionably	possibly
rarely	relatively	seldom	sometimes
somewhat	surely	undeniably	undoubtedly
unlikely	usually	virtually	
apparent	certain	clear	definite
doubtful	doubtless	evident	impossible
improbable	incredible	indefinite	inevitable
likely	obvious	plain	possible
predictable	probable	uncertain	(un) questionable
risky	sure	in question	unlikely
assumption	belief	certainty	chance
claim	danger	doubt	estimate
evidence	explanation	possibility	hope
idea	opinion	fear	probability
risk	speculation	tendency	uncertainty

Appendix 3. Pair wise Comparisons of sources of uncertainty

(I) factor1	(J) factor1	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
S1	S2	-0.485*	0.074	0.000	-0.702	-0.268
	S3	0.156*	0.048	0.029	0.016	0.296
S2	S1	0.485*	0.074	0.000	0.268	0.702
	S3	0.641*	0.043	0.000	0.515	0.768
S3	S1	-0.156*	0.048	0.029	-0.296	-0.016
	S2	-0.641*	0.043	0.000	-0.768	-0.515

Note: Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Adjustment for multiple comparisons: Bonferroni.

S1 = Incomplete information

S2 = Inadequate understanding

S3 = Undifferentiated alternatives

Appendix 4. Wilcoxon *post hoc* test on types of uncertainty with *Bonferroni correction*

	T2 - T1	T3 - T1	T4 - T1	T3 - T2	T4 - T2	T4 - T3
Z	-1.989E0	-2.666E0	-2.803E0	-.663[a]	-2.805E0	-2.803E0
Asymp. Sig. (2-tailed)	0.012	0.002	0.001	0.127	0.001	0.001

Note : a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

T1 = State uncertainty

T2 = Effect uncertainty

T3 = Response uncertainty

T4 = Nothing

Appendix 5. Ranks of types of uncertainty

	Mean Rank
State uncertainty	3.65
Effect uncertainty	2.80
Response uncertainty	2.55
Nothing	1.00

Appendix 6. Wilcoxon *post hoc* test on types of uncertainty with *Bonferroni correction*

	C2 - C1	C3 - C1	C4 - C1	C5 - C1	C6 - C1	C7 - C1	C3 - C2	C4 - C2	C5 - C2	C6 - C2	C7 - C2
Z	-2.090E0	-2.547E0	-2.293E0	-2.803E0	-2.293E0	-2.803E0	-2.073E0	-2.191E0	-2.666E0	-2.073E0	-2.803E0
Asymp. Sig. (2-tailed)	0.005	0.002	0.003	0.001	0.003	0.001	0.005	0.004	0.001	0.005	0.001

	C4 - C3	C5 - C3	C6 - C3	C7 - C3	C5 - C4	C6 - C4	C7 - C4	C6 - C5	C7 - C5	C7 - C6
Z	-.405[b]	-.840[a]	-.338[b]	-2.023E0	-.980[a]	-.365[b]	-2.023E0	-1.260E0	-1.572E0	-2.201E0
Asymp. Sig. (2-tailed)	0.098	0.057	0.105	0.006	0.047	0.102	0.006	0.029	0.017	0.004

Note a. Based on positive ranks.

b. Based on negative ranks.

c. Wilcoxon Signed Ranks Test

C1 = Natural environment

C2 = Technological advances

C3 = Human behaviors

C4 = Market

C5 = Policy

C6 = Internal organization

C7 = Nothing

Appendix 7. Ranks of categories of uncertainty

	Mean Rank
Natural environment	6.25
Technological advances	5.65
Human behaviors	3.55
Market	3.60
Policy	3.05
Internal organization	3.90
Nothing	2.00