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Non-monetary incentives for sustainable biomass harvest: An experimental approach

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Abstract

In this article, we use a contextualized lab experiment to test the effect of non-monetary incentives that can guide harvest professionals into adopting new sustainable harvesting practices. First, we test the effect of signing a declaration that commits wood buyers who voluntarily sign it to act in a sustainable manner. Second, we test the effect of priming by activating a concept of sustainability on subjects' behaviour. Our results provide evidence that presenting a declaration to sign is effective in inducing subjects to act in a sustainable manner when personal and collective interests are not aligned and there are financial incentives to make decisions that are against environmental sustainability. However, sustainability priming does not have a significant impact on subjects' behaviour. From a public policy point of view, a declaration is an effective tool and easy to implement by institutions aiming at fostering pro-environmental behaviour.

Keywords Forest; Timber harvest; Laboratory experiment; Non-monetary incentives; Commitment; Priming

JEL Classification C91; Q23; Q56

1 Introduction

Climate change impacts resulting from fossil fuel combustion have sparked global interest to switch to renewable energy sources that would reduce greenhouse gas emissions. One important energy source option is biomass. Recently, wood harvesting has been considerably growing to meet the European countries' targets for renewable energy production (EU, 2009). During the last decade, the number of wood fuelled power plants (for heating and/or electricity) increased significantly. ADEME (The French Agency for Ecological Transition) estimated that from 2013 to 2018 the number of power installations larger than 100 tonnes of oil equivalent/year will increase from 332 to 685 and that the consumption of wood chips from forests will increase from 2.3 Mt to 6.3 Mt for the same period (ADEME, 2016, p.11-12). This increase is expected to continue the decades to come (Colin & Thivolle-Cazat, 2016, p.76). However, an increase in biomass harvest

could result in several environmental issues such as: younger forests, lower biomass pools, depleted soil nutrient stocks and a loss of other ecosystem functions (Schulze et al., 2012). Additionally, wood fuels harvesting often consists of harvesting whole trees as well as that of the residues from thinning and final felling. However, the removal of small branches as a result of whole-tree harvesting and the use of harvest residues have raised concerns about the depletion of nutrients in forest ecosystems and adversely affecting soil fertility and tree growth in the long term (Achat et al., 2015). Indeed, studies show that leaving small branches in the forest reduces the loss of nutrient significantly (Paillet et al., 2013).

To preserve soil fertility and biodiversity, the evolution of traditional harvest practices has become a priority (Bouget et al., 2012). That's why ADEME updated the existing environmental recommendations of 2006 on harvesting practices of forest biomass for energy (Cacot et al., 2006). Nevertheless, discussions with forest professionals involved in the mobilisation of forest biomass reveal that the recommendations are often not applied.¹ It might seem surprising that not all forest owners will ensure that the biomass harvesting is done according to ADEME recommendations as they will carry the long-term productivity loss of their forest. This could be explained by two main reasons. First, the size of private forests in France is small, i.e. half of the private forest land is owned by forest owners having less than 25 hectares (Le Jeannic et al., 2015, p.9). Second, many forest owners are “passive” owners, e.g., 28% of the forest owners have not been harvesting timber the last 5 years and timber production is not the main objective for about two third of all forest owners (Le Jeannic et al., 2015, p. 29, Petucco et al., 2015). Therefore, forest owners either do not care about the long term effects of harvesting or are unaware of these effects. Furthermore, harvest is usually carried out by a wood buyer who is generally well informed about potential negative effects of harvesting but do not have any interest in informing the forest owner since accounting for the negative effects implies higher harvest costs or no harvest.²

The aim of this paper is to identify experimentally different types of non-monetary incentives that can guide the behaviour of harvest professionals into adopting the new sustainable harvesting

¹This discussions took place in three stakeholder meetings: regional meetings on the 7th of March and 12th of April 2019 in Champagne Ardennes region and a national one on 30th of April 2019 in Paris.

²In some cases, a forest expert or a cooperative may serve as an intermediary between the forest owner and the wood buyer.

practices.³ Our main contribution lies in testing the effect of non-monetary incentives in a contextualized experiment which findings can be applied to a specific real-life problem i.e applying sustainable wood harvesting practices. Traditional economic incentives raised a concern regarding “crowding out” intrinsic motivations (Frey, 1992; Gneezy & Rustichini, 2000; Benabou & Tirole, 2003; Bénabou & Tirole, 2006). The crowding out hypothesis started with Titmuss (1971) who found that individuals are more likely to donate blood when they do so voluntarily through intrinsic motivation, rather than in the presence of monetary incentives. The crowding out effect is also relevant in environmental behaviour such as resource use, modes of mobility, and consumption decisions, including boycotts of environmentally harmful products (Lewis, 2008; Rode et al., 2015). Additionally, monetary incentives have failed to produce long-lasting changes in environmental behaviour (Lefebvre & Stenger, 2020). When stopped, some behaviours tend to be worse than before the implementation of monetary incentives. Moreover, the absence of enforcement cost in non-monetary incentives made them more convenient to reach environmental objectives in a cost-effective way. Hence, non-monetary incentives have received a growing interest. Non-monetary incentives are often related to the concept of “nudges” (Thaler & Sunstein, 2009).⁴ Green nudges in particular had shown to be effective in guiding behaviour to make more sustainable decisions, e.g., the default option (Löfgren et al., 2012), social comparison (Allcott, 2011) and commitment (Baca-Motes et al., 2013). Additionally, Ouvrard et al. (2020) used nudges as an instrument to increase social acceptability of application of wood ash in forests. The authors found that nudges, in particular positive framing and productive wording, influence the willingness-to-pay but depend on the attitudes of the respondents.

In this article, we use a contextualized laboratory experiment with student subjects to test the impact of non-monetary incentives on pro-environmental behaviour, that is applying sustainable harvest practices in our context. A common criticism of laboratory experiments is that the decision situation is too abstract and differs too much from real-world decisions, which jeopardizes the external validity of the findings (Harrison & List, 2004; Murnighan & Wang, 2016). We chose to

³New sustainable harvesting practices include, for example, allow the wood to dry out on the plot before skidding or leave some of the small wood from felled trees on the ground (Landmann et al., 2018).

⁴A nudge is defined by Thaler & Sunstein (2009) as an “aspect of the choice architecture that alters people’s behaviour in a predictable way without forbidding any options or significantly changing their economic incentives”.

do a contextualized experiment because meaningful context can both enhance the understanding of the experiment and reduce confusion among participants, making choices more consistent or strategic (Alekseev et al., 2017). At the same time, placing subjects in a decision situation highly similar to the real-life decision improves the external validity of the results, because it is easier for subjects to imagine themselves in that situation. Previous studies have used contextualized laboratory experiments to make the situation more realistic for the subjects, and/or to help them understand a complex design (Camacho-Cuena & Requate, 2012; Krawczyk et al., 2016; N. V. Czap et al., 2015; H. J. Czap et al., 2018).

The context of our experiment is inspired by one of the problems raised during meetings with stakeholders which is that a small private forest owner may be relatively uninformed about the importance of following sustainable harvesting recommendations. The wood buyer therefore faces a dilemma. If the buyer decides to follow the recommendations, this implies higher harvesting costs and therefore lower payment to the forest owner. The latter may turn to another wood buyer who does not follow the recommendations and who is able to pay a higher price for the cut. Thus, the wood buyer has a strong economic incentive to not to follow the recommendations. Nevertheless, following sustainable harvesting recommendations is not only in the interest of the forest owner but also for the public interest as it maintains soil fertility and preserves biodiversity (Landmann, 2020). Hence, these positive externalities make following sustainable harvesting recommendations a public good. It is then necessary to provide wood buyer with incentives to act in accordance with the forest owner and the public interests. Moreover, given the public good aspect of sustainable harvest, these incentives should be implemented by a third party such as a public institution or NGO.

We test the effect of two non-monetary incentives that can change wood buyer’s behaviour into acting in a more sustainable manner. First, we will use a non-monetary incentive inspired by the social psychology theory of commitment. Designing a declaration that aims to commit wood buyers who voluntarily sign it into acting in a sustainable manner. This practically means to harvest whole trees only when soil sensitivity is low.⁵ Wood buyers are free to sign or not the declaration. The

⁵When soil sensitivity is moderate to high, harvesting whole trees can have a negative impact on soil fertility on the long run, however when soil sensitivity is low, harvesting whole trees can be done without harming the soil

theory of commitment shows that preparatory acts “link” people to their decisions in subsequent choice environments (Kiesler, 1971; Joule et al., 2007). Our hypothesis is that the preparatory act, i.e signing the declaration, will create commitment. The approach of signing a declaration prior to the task to induce commitment has been used in Voluntary Contribution Game in Bazart et al. (2019). It is close to the “solemn oath” technique proposed by Jacquemet et al. (2013, 2018, 2019) used as an *ex ante* truth-telling commitment device. Taking oath was found to increase sincere bidding behaviour (Jacquemet et al., 2013), increase truth telling in coordination games with cheap talk communication (Jacquemet et al., 2018) and enhance sincere behaviour when lies were made explicit (Jacquemet et al., 2019). Moreover, commitment via signing a statement was used to promote energy conservation (Pallak & Cummings, 1976), recycling (Burn & Oskamp, 1986), safety belt use (Geller et al., 1989), pedestrian safety (Boyce & Geller, 2000) and weight loss (Nyer & Dellande, 2010). **The context in which the effect of declaration is tested differs from previous studies in two aspects. First, subjects sign a declaration to commit to act in a sustainable manner. Second, the outcome of a subject’s decision does not only depend on her own decision but also on that of others.**

Second, additional to the commitment approach, we used an implicit priming task to induce subjects to act in a sustainable manner. Priming is a well-known instrument in laboratory setting in social psychology to change human behaviour. It enables the measurement of the pure psychological impact of the primed concepts on behavior (and emotions and cognition) in subsequent tasks (Cohn et al., 2015). Thus far, a few studies have examined how priming on trust, cooperation and identity norms affect economic outcomes (Burnham et al., 2000; Benjamin et al., 2010; Huang & Murnighan, 2010; Drouvelis et al., 2015). There are many implicit priming techniques including the unscrambling of sentences, background music and images, odors, temperature, and subliminal stimuli (Cohn & Maréchal, 2016). The priming task that we use is close to the scrambled-sentence priming procedure. De-Magistris et al. (2013) used a scrambled-sentence honesty priming task to help mitigate potential hypothetical bias in hypothetical choice experiments (CE). Additionally, Kay & Ross (2003) used scrambled-sentences priming tasks related to cooperation and competition (Cacot et al., 2006).

to see their effect on subjects' perception of a Prisoners Dilemma game.

The difference between commitment and priming is that in the commitment approach, the person has to freely choose to “prime her/himself”. However, our priming attempts to automatically activate a subject’s awareness of sustainability issues without the need for a direct consent. These two instruments act differently on two families of cognitive operations in the human mind. Priming targets System 1, which is fast, automatic, and intuitive. However, signing the declaration targets System 2 which is slow, calculative, and deliberative (Kahneman, 2011). Nudges that target System 2 might seem better, because they help people to reflect, or to improve their deliberative capacities (Sunstein, 2016). We aim to answer the following question: does priming a concept of environmental awareness and/or signing a declaration induce people to make more sustainable decisions in a context where personal and collective interests are not aligned and where there are clear financial incentives to make a decision that is against environmental sustainability? In this paper, we will test the efficiency of each incentive, signing a declaration and priming: Priming that activates a concept of environmental awareness when being exposed to subtle cues and asking subjects to activate their own environmental awareness by committing themselves to do so through signing a declaration. *To our knowledge, no previous study has investigated the effect of these two non-monetary incentives on pro-environmental behaviour in the same framed laboratory experiment.*

Given this context, it is essential to find in our experiment an optimal compromise between the simplicity of the experiment focusing on the hypotheses to be tested regarding the non-monetary incentives and the presence of a sufficient context to ensure that the results can be transferred to a specific situation (the wood-energy sector). Our experimental design does not represent all possible situations and relationships between forest owners and wood buyers. We focus on small forest owners (the majority in the value chain) who are generally unaware of the sustainable wood energy harvesting recommendations or who will not have the capacity or willingness to carry out a soil diagnostic. There are, of course, small private forest owners who may either be informed and concerned about the potential impact of biomass harvesting on their forest soils, or use forestry experts as intermediaries between them and wood buyers.

The rest of the paper is structured as follows. Section 2 describes the experimental design and the treatments. Section 3 presents the hypotheses to be tested. Section 4 reports the results. Section 5 discusses the results and concludes.

2 Experiment

2.1 Context

Landmann et al. (2018) present recommendations for sustainable harvesting practices for wood energy. In young forest stands, whole-tree harvesting is often the only profitable harvesting method to produce wood fuels. This type of harvesting also involves removing the small woods (i.e. foliage and branches less than 7 cm long) usually left on the ground in the forest when harvesting timber. However, these small woods contain a significant amount of minerals necessary for soil fertility. Thus, removing them can harm soil fertility on the long run. This is why ADEME advises against harvesting whole trees for the most sensitive soils. For the sake of simplicity, we classify soil sensitivity in the experiment into two categories: “moderate to high” or “low”.

- If the soil sensitivity is *moderate to high*, harvesting small woods (foliage and branches) is strongly not recommended. Since the stock of nutrients in the soil is low, a removal of nutrients through biomass harvesting reduces significantly soil fertility and the forest owner loses future timber productivity.
- On the other hand, if the soil sensitivity is *low*, wood can be harvested as whole trees without particular care regarding removing small trees. The forest owner then can make a profit of harvesting.

To find out the soil type, the wood buyer must make a soil diagnostic before harvesting.⁶ Wood buyers are therefore perfectly informed about soil types and are able to recommend forest owners

⁶In reality, the wood buyer will have the choice of whether or not to do the soil diagnostic before making an offer to purchase the wood. Diagnostic has a cost (essentially an opportunity cost in time), so the buyer may have an incentive not to do a diagnostic if it is not required by the forest owner. However, in our experience, this decision to make or not a diagnostic is not qualitatively different from the decision to comply with the results of the diagnostic.

whether or not to harvest small woods.⁷ Forest owners are passive, in a sense that they follow blindly the recommendation of the wood buyer to harvest or not. Buyers only make a profit when they recommend to forest owners to harvest whole trees regardless of soil type. On the other hand, forest owners, if informed, would prefer whole trees to be harvested only when soil sensitivity is “low”, yet they cannot accurately observe their soil type but must rely on the buyers’ diagnostic. If whole trees harvesting is done when soil sensitivity is “moderate to high”, the forest owner loses soil fertility on the long run with negative effects on timber productivity and on other services provided by the forests, e.g., preserving biodiversity.

The wood buyer has the choice between two different actions. First, harvesting whole trees without considering soil sensitivity in order to make a profit from the harvest at the potential expense of soil fertility on the long run. Second, only harvesting if soil sensitivity is low to avoid losing soil fertility of the most sensitive soils on the long run. Additionally, wood buyer’s action affects not only his/her well-being but also the public interest. If the wood buyer recommends to harvest whole trees when the soil sensitivity is moderate to high, he/she makes a profit, however, the soil will lose its fertility on the long run which is not aligned neither with the public nor forest owners’ interest.

2.2 Design

Our experimental design is inspired by [Rud et al. \(2018\)](#) which aims to determine whether market structure affects financial intermediary behaviour.⁸ We had two types of actors: wood buyers and forest owners. All subjects in the session played the role of wood buyers who would

⁷In the terminology of the experiment, we assume that the wood buyer has only two options when the diagnostic indicates that the soil sensitivity is moderate to high: to harvest or not to harvest. In reality, the wood buyer could choose to harvest but following the recommendations and paying a price below the market price to compensate for the higher costs. However, for the sake of simplicity, we have ignored this option. The assumption is that if the buyer offers a price lower than the market price, based on the cost of harvesting on more sensitive soils, the forest owner will reject the offer and no harvest will take place.

⁸In the experiment of [Rud et al. \(2018\)](#), financial advisers (Agents) manage portfolios on behalf of the clients (Principals) for which they receive a fee. Agents can recommend that the Principals either Continue or Stop an investment project, which can be either high value or low value project. Principals would prefer to invest only in high value projects. However, they cannot observe whether the project is high value or low value. Agents, on the other hand, can perfectly observe the project type before issuing a recommendation. The Principals are gullible. They are robots that completely trust Agent recommendations.

make a recommendation to “harvest” or not to “harvest” to forest owners. Forest owners are fictive and passive actors that undergo the recommendation of the wood buyer to harvest or not. Forest owners’ earnings were given to: Reforest’Action, a social enterprise whose mission is to raise awareness and take action for the forests.⁹ The amount transferred to Reforest’Action is used to plant trees in a forest restoration project in Meurthe et Moselle and Bas-Rhin in France and subjects were aware of this in the instructions and were shown a photo of the site of the plantation. Hence, subjects’ decisions had a real impact on the environment and forest restoration.

Subjects faced 10 periods. Only one of these 10 periods was selected for payment at the end of the experiment. In each period, to illustrate the competition between wood buyers, a wood buyer will be a part of a group of 3 forest owners and 3 wood buyers (including him/her).¹⁰ The groups changed from one period to another in order to remove any potential reputation concerns and punishment possibilities from the previous period. In each period, each forest owner was assigned to a wood buyer in the group. The forest owner would obtain a recommendation to “harvest” or not to “harvest” from the wood buyer. The probability of having a soil with moderate to high sensitivity was 60% and the probability of having a soil with low sensitivity was 40%.¹¹ Wood buyers had access to information about the exact type of soil in each period, while forest owners did not have this information. Soil sensitivity was the same within a group.

After observing the soil type, buyers then made a recommendation to the forest owner whether or not to harvest. If the harvest was done, the value of the biomass from the harvest = 100 ECU. The buyer got 50% of the biomass value. A buyer’s payoff did not depend on soil sensitivity but only on his/her decision (to harvest or not) and the number of owners assigned to him, explained later on. A forest owner’s payoff depended on soil sensitivity and whether or not harvesting took place. Harvesting took place if at least one of the buyers in the group has recommended harvesting to the forest owner assigned to him/her. Table 1 shows the payoffs of the wood buyer (WB) and the forest owner (FO).¹²

⁹This is similar to donation to the environment in Dorner (2019).

¹⁰We run sessions of 24 subjects. Groups of 3 wood buyers are made out of supergroups of 12 subjects.

¹¹There is a large variability in the percentage of sensitive soil across regions in France (Augusto et al., 2018, p.35-36). In some regions, the percentage of sensitive soil is 60%.

¹²In this table, we do not take into account FO’s initial endowment which is his/her natural capital of 50 ECU.

Table 1 Payoff in ECU

	Soil sensitivity is moderate to high		Soil sensitivity is low	
WB decision	Payoff of WB	Payoff of FO	Payoff of WB	Payoff of FO
Harvest	50	-50	50	50
Not to harvest	0	0 (-50) ^a	0	0 (50) ^b

^a 0 if the 3 WBs of the group recommended not to harvest and -50 if at least one WB recommended to harvest.

^b 0 if the 3 WBs of the group recommended not to harvest and 50 if at least one WB recommended to harvest.

Figures 1 and 2 show different scenarios of payoffs of wood buyers and forest owners in a group when soil sensitivity is moderate to high and low respectively and accounting for the competition between wood buyers. In Figure 1, if WB1 recommends harvesting, while the other 2 buyers in the group WB2 and WB3 recommend not harvesting, the forest owners of these buyers will be reassigned to buyer WB1. WB1 therefore harvests with 3 forest owners and gets a payoff of $50\% \cdot 100 \cdot 3 = 150$ ECU. However, the 3 forest owners will lose their natural capital of 50 ECU and gain 0 ECU. If both buyers WB1 and WB2 recommended harvesting, while buyer WB3 recommended not harvesting, WB3's forest owner will be randomly reassigned to one of the two buyers (WB1 or WB2). If reassigned to WB2, he/she gets a payoff of $50\% \cdot 100 \cdot 2 = 100$ ECU. WB1 gets 50 ECU and WB3 gets 0 ECU. If the 3 buyers recommend harvesting to their forest owners, the payoff of each buyer is 50 ECU. To prevent the loss of soil fertility for the forest owner, the 3 buyers should recommend not to harvest.

In Figure 2, the optimal outcome is obtained when the 3 buyers recommend harvesting to their forest owners. The payoff of each buyer is then 50 ECU and the forest owner gets a payoff of 100 ECU. To summarize, our design has an aspect of a dictator game and another aspect of a public good game. It resembles a dictator game as wood buyers are decision makers and forest owners are passive recipients having no influence over their payoff. Nevertheless, it resembles a public good game since the payoff of a forest owner, i.e. donations to forest restoration, depends on the decisions of all of the three wood buyers in the group.

2.3 Treatments

2.3.1 Commitment

To generate a commitment effect, subjects were provided, before starting the experiment, individual sheets of paper on which they had to formally sign a statement. They took their time to read alone and decide whether to accept the statement or not, away from the experimenter in order to avoid any social pressure that the experimenter, as an authority, implicitly puts on a subject (Zizzo, 2010).

In this statement, shown in Figure 3, they can choose to commit (or not) to make recommendations consistent with sustainable harvesting practices throughout the game. Declarations were anonymous in a sense that we could not know whether a subject in particular has agreed or not to this statement and subjects knew about this. However, we were able to know the number of participants who have agreed and signed this statement. 60.42% of the subjects (58 out of 96) agreed on the statement and signed the declaration.¹³

2.3.2 Priming

Before starting the experiment, subjects were asked to complete each of 24 sentences by the adequate word from a list of 3 words. Two different priming treatment conditions were defined, a neutral priming task and a sustainability priming task. In the sustainability task, 16 out of 24 sentences were related to sustainability, while in the neutral task, all the sentences rather correspond with general topics (sentences are available in appendix A.1 and A.2). We added the neutral priming to test and ensure that the effect did not arise purely due to adding a certain task prior to the game, but rather due to the nature of the task and the activation of sustainability concepts. Selection of the sustainability priming words was based on a pre-test in which 33 words were judged regarding their relatedness to sustainability as in Drouvelis et al. (2015). We asked a

¹³The result of 39.58% of subjects chose to not to sign the declaration is higher than what we see in the literature. This result might be due to the specific context of our framed laboratory experiment and the nature of our declaration compared to the truth-telling oath of Jacquemet et al. (2013) and Jacquemet et al. (2018) or commitment to act in a prosocial manner in a Voluntary Contribution Game of Bazart et al. (2019).

group of 25 individuals to choose 15 out of 33 words that are the most related to sustainability. The selected words were those that were chosen the most (the complete list of the 33 words used is provided, along with the number of times they were chosen in appendix A.3).

2.4 Social Value Orientation (SVO) (Murphy et al., 2011)

To elicit social preferences, we used the Social Value Orientation (SVO) slider measure (Murphy et al., 2011). This allows to classify participants in different categories: competitive (maximizes the difference between own and other payoff), individualist (maximizes own payoff), prosocial (maximizes joint-payoff) and altruist (maximizes other’s payoff). The SVO measure consists in 15 allocation decisions between a decision-maker and a passive player. The responses determine a subject’s SVO angle where a higher value indicates higher pro-sociality. All participants made 15 choices as the decision maker. They were paid for two randomly selected periods: one as the decision maker, one as the passive player. In the analysis, we use the continuous SVO angle as a predictor variable because it has a higher resolution than the categorical dimensions.

According to Murphy et al. (2011), altruists would have an angle greater than 57.15; prosocials would have angles between 22.45 and 57.15; individualists would have angles between -12.04 and 22.45; and competitive types would have an angle less than -12.04.

2.5 General Ecological Behavior (GEB) scale (Kaiser, 1998)

Subjects completed a questionnaire to determine their environmental sensitivity. To save time, we selected 28 of 40 items (detailed in appendix B) from the General Ecological Behavior (GEB) scale (Kaiser, 1998). The reduced version with 28 questions was proposed by Davis et al. (2009, 2011) and used in My & Ouvrard (2019).¹⁴ Seventeen items were framed positively and the 11 remaining ones negatively. The subjects had to give their level of agreement to each item using 5 possible answers: *never*, *seldom*, *sometimes*, *often* and *always*. The answers were recoded from 1

¹⁴This shorter version presents an acceptable reliability when measuring Cronbach’s alpha: $\alpha = 0.76$ in Davis et al. (2009), $\alpha = 0.75$ in Davis et al. (2011) and $\alpha=0.74$ in My & Ouvrard (2019).

for *never* to 5 for *always* for ecological items and the opposite for unecological items.

2.6 Procedures

We conducted 24 experimental sessions at the Laboratory of Experimental Economics of Strasbourg (LEES) where in total 384 subjects participated.¹⁵ In a between-subjects design, we implemented 4 treatments: baseline, signing declaration, neutral priming and sustainability priming. In each treatment, 96 subjects participated. While 30 subjects per treatment is often used as rule of thumb in economic experiments (List et al., 2011), we wanted to account for potential dependence between subjects as they are paired in groups and decided to have 96 subjects per treatment. Subjects were recruited from a list of experimental subjects of the LEES using the ORSEE software (Greiner, 2015).

The instructions were read aloud by the experimenter and before starting, a comprehension questionnaire was administered to check for subjects' understanding of the decision task. If a subject gave a wrong answer, the right answer was highlighted and explained to ensure that they fully understand the task.

Subjects were paid in private in cash according to the randomly determined decisions. Students earned €18.8 on average. The total amount transferred to Reforest'Action was €1080. Thus, our experiment provided money for planting 360 trees in Meurthe et Moselle and Bas-Rhin regions in France. At the end of the experimental sessions, we sent students a receipt of the transfer to Reforest'Action.

3 Hypotheses

H1: The treatment of signing the declaration decreases the proportion of choices recommending to harvest when soil sensitivity is moderate to high.

¹⁵We conducted 8 sessions in 2020 and 16 sessions in 2021. Due to the COVID-19 constraints, sessions were postponed in 2020. We were then able to conduct our sessions starting February 2021.

H2: Sustainability priming decreases the proportion of choices recommending to harvest when soil sensitivity is moderate to high.

H3a: Subjects with higher environmental sensitivity harvest less when soil sensitivity is moderate to high.

Some studies have found a positive relationship between environmental attitude and pro-environmental behaviour (Schlegelmilch et al., 1996; Straughan & Roberts, 1999; Kollmuss & Agyeman, 2002). Hence, we expect subjects with higher environmental sensitivity to act sustainably i.e. not recommending to harvest when soil sensitivity is moderate to high.

H3b: The effect of signing a declaration is higher for subjects with higher environmental sensitivity to be consistent with their preferences.

H4a: Subjects with higher social value orientation (SVO) recommend less to harvest when soil sensitivity is moderate to high.

Pro-environmental attitudes and behaviours have been shown to be positively related to altruistic values, while negatively related to egoistic values (Straughan & Roberts, 1999; Stern & Dietz, 1994; Nordlund & Garvill, 2002). Hence, we use SVO to measure the degree of altruism and expect it to have a positive impact on pro-environmental behaviour, decreasing the probability to harvest when soil sensitivity is moderate to high.

H4b: The effect of signing a declaration is higher for subjects with higher SVO score as altruism amplifies the effect of the treatment.

4 Results

4.1 Treatments effect

Table 2 summarizes the proportion of choices recommending to harvest when soil sensitivity is moderate to high per treatment. Recommending to harvest when soil sensitivity is moderate to high is against environmental sustainability as it decreases soil fertility on the long run. Using a

proportion test, we find a significant difference between the proportion of choices recommending to harvest in signing a declaration treatment (SR) (69.7%) relative to the baseline (82.2%) at 1% significance level (P-value= 0.009) (**Result 1**). Our findings suggest that the declaration has potential to create the commitment needed to act in a sustainable way.

Moreover, using a non-parametric test for proportions, we find that priming decreases the proportion of choices recommending to harvest.¹⁶ However, the difference between the proportion of choices recommending to harvest in sustainability priming treatment (SP) (75%) and that of the neutral priming (NP) (80.8%) is not significant (P-value=0.123) (**Result 2**).

Table 2 Proportion of choices recommending to harvest when soil sensitivity is moderate to high.

Treatment	Proportion	<i>N</i>
Baseline (BL)	0.822	585
Declaration Signing (SR)	0.697, P-value= 0.009	561
Neutral Priming (NP)	0.808	588
Sustainability Priming (SP)	0.750, P-value= 0.123	576

N is the number of periods when soil sensitivity is moderate to high.
Standard errors are clustered at the subject level.

Figure 4 shows the share of subjects who recommended to harvest when soil sensitivity is moderate to high per period across treatments. This share increases over time across treatments. This share starts from about 72% in the Baseline then continuously increases until period 10 to reach 90%. Overall, the share of subjects who recommended to harvest in the treatment of signing a declaration is below that of the baseline.

4.2 Environmental sensitivity & SVO

We report the results from the GEB questionnaire used to measure subjects' environmental sensitivity. We calculated a score for each subject, ranging from 1 to 5, based on their responses

¹⁶Non-parametric statistical tests are useful to analyze experimental data as they are non-normally distributed and measured on a binary scale rather than an interval scale (Feltovich, 2003).

for the 28 items. The mean score for all subjects was 3.88 (SD = 0.385), ranging between 2.607 and 4.607. Overall, the GEB scale was found to be acceptable when measuring the Cronbach's alpha ($\alpha = 0.77$). Then, subjects were categorized according to their level of environmental sensitivity. Subjects whose scores were below the mean were considered as the least sensitive to environmental matters. Subjects with a score above the mean were considered as the most sensitive to environmental matters. 56% of subjects have high sensitivity to environmental matters.

The SVO angle is calculated by computing the mean amount a participant allocates to himself/herself and the mean allocation for the other participant. Afterwards, the value of 50 is subtracted from both means.¹⁷ Subsequently, the ratio between these means (i.e. mean other/mean self) is computed, and finally the inverse tangent of this ratio is calculated, resulting in an individual SVO angle which we refer to as SVO score. SVO scores vary between -6.009 and 46.860. The majority of subjects in our sample (364 subjects) are individualists having SVO score lower than 22.45 and higher than -12.04. Only 20 subjects are considered as prosocial having SVO score higher than 22.45 and lower than 57.15. There were neither altruist (having a score higher than 57.15) nor competitive (having a score lower than -12.04) subjects in our sample.

Table 3 Summary Statistics

	Mean	SD	Min	Max
Average Environmental Sensitivity Score	3.877	0.385	2.607	4.607
High Environmental Sensitivity	0.560	0.497	0.000	1.000
SVO Score	9.083	8.608	-6.009	46.860
<i>N</i>	384			

4.3 Econometric analysis of the decision to harvest

Table 4 presents multi-level mixed effects logit model (using Stata's `melogit` command) where the dependant variable is the decision of the wood buyer recommending to harvest when soil sensitivity is moderate to high (=1 if a buyer recommended to harvest, 0 otherwise). [This model](#)

¹⁷For a detailed explanation of the calculation, see [Murphy et al. \(2011\)](#)

captures heterogeneity at different levels: supergroup level¹⁸ and subject level, by including random intercepts for each level and therefore avoid misspecification due to within group correlations. While the subject effect is due to subject heterogeneity, the supergroup effect may arise as subjects with the same observable characteristics in different supergroups may have a different predicted probability of recommending to harvest. This model confirms the significant effect of signing a declaration. Signing a declaration that commits subjects to act sustainably decreases the probability of recommending to harvest when soil is sensitive at 1% significance level in specification 1 and 5% significance level in specification 2, 3 and 4. Additionally, having a high environmental sensitivity decreases the probability of recommending to harvest when soil is sensitive at 5% significance level (**Result 3a**). Hence, high environmental sensitivity induces pro-environmental decisions. This result confirms that subjects understood the game and acted as predicted by **H3a**. However, contrary to **H4a**, we found no significant impact of SVO score on the probability of recommending to harvest (**Result 4a**). The interaction terms between the declaration treatment and high environmental sensitivity, and the declaration treatment and SVO score, respectively, were not statistical significant. This indicates that the effect of the declaration treatment does not depend on environmental sensitivity or social value orientation (**Result 3b and 4b**). Furthermore, we find that the first specification without interaction terms provided the best fit to the data by comparing the Akaike information criterion (AIC), Bayesian information criterion (BIC) and Wald Chi-squared statistics.

The variable “Lag_Harvest” shows the number of partners in the group that recommended to harvest in the previous period where soil sensitivity is moderate to high. It can take the values of 0, 1 or 2. We believe that partners’ behaviour in the previous period had an impact on a subject’s decision in the current period, even if groups changed from one period to another. We found that having 1 or 2 partners in the group that recommended to harvest in the previous period increases the probability of recommending to harvest in the current period compared to having 0 partners recommending to harvest. This finding highlights that social influence has a considerable impact on a wood buyer’s decision.

¹⁸In each session of 24 subjects, groups of 3 wood buyers were formed out of supergroups of 12 subjects. In our sample of 384 subjects, we have 32 supergroups of 12.

We also found that time is significant at 1% significance level and increases the probability of recommending to harvest. Subjects recommended to harvest more in the last periods of the experiment compared the early ones. Moreover, the subject-level random effects are significant, indicating that subject level characteristics are important to be considered. However, **supergroup** level random effects are not significant.

Table 5 shows the marginal effects at the means for the first specification of the model. For an average subject, being in the treatment of signing a declaration decreases the probability of recommending to harvest by 13.3%. Additionally, having a high environmental sensitivity relative to low sensitivity decreases the probability of recommending to harvest by 6.6%. Moreover, having 1 or 2 partners in the group that recommended to harvest in the previous period increases the probability of recommending to harvest in the current period by 6% and 8.5% respectively. Finally, time period increases the probability of recommending to harvest by 1.4%

Table 4 Multi-level mixed effects logit model for the probability to harvest when soil sensitivity is moderate to high

	(1)	(2)	(3)	(4)
Neutral Priming	-0.150 (0.780)	-0.126 (0.814)	-0.124 (0.819)	-0.108 (0.841)
Signing Declaration	-1.489*** (0.006)	-1.557** (0.027)	-1.796** (0.013)	-1.921** (0.029)
Sustainability Priming	-0.582 (0.278)	-0.022 (0.974)	-1.084 (0.133)	-0.467 (0.607)
High env. sensitivity	-0.803** (0.022)	-0.831** (0.018)	-1.168** (0.023)	-1.146** (0.026)
SVO Score	0.012 (0.554)	0.025 (0.365)	0.013 (0.515)	0.024 (0.402)
Lag_Harvest=1	0.668** (0.042)	0.670** (0.042)	0.671** (0.042)	0.671** (0.042)
Lag_Harvest=2	0.971*** (0.004)	0.978*** (0.004)	0.977*** (0.004)	0.982*** (0.004)
Period	0.174*** (0.000)	0.174*** (0.000)	0.174*** (0.000)	0.174*** (0.000)
Signing Declaration \times SVO Score		0.008 (0.868)		0.012 (0.804)
Sustainability Priming \times SVO Score		-0.061 (0.204)		-0.054 (0.270)
Sustainability Priming \times High env. sensitivity			0.867 (0.301)	0.652 (0.446)
Signing Declaration=1 \times High env. sensitivity			0.527 (0.529)	0.566 (0.501)
Constant	1.769*** (0.004)	1.648*** (0.009)	1.971*** (0.002)	1.851*** (0.006)
Supergroup-level constant	0.271 (0.388)	0.252 (0.413)	0.269 (0.392)	0.257 (0.406)
Subject-level constant	7.719*** (0.000)	7.689*** (0.000)	7.694*** (0.000)	7.656*** (0.000)
N	1926	1926	1926	1926
Log-Likelihood	-736.984	-736.097	-736.454	-735.733
AIC	1495.968	1498.194	1498.908	1501.465
BIC	1557.163	1570.516	1571.229	1584.913
Wald χ^2	53.17***	54.55***	53.81***	54.93***

p-values in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5 Marginal effects at the means

Neutral Priming	-0.0125 (-0.28)
Signing Declaration	-0.133** (-2.57)
Sustainability Priming	-0.0495 (-1.06)
High env. sensitivity	-0.0658** (-2.34)
SVO Score	0.000971 (0.59)
Lag_Harvest=1	0.0605** (1.96)
Lag_Harvest=2	0.0854*** (2.69)
Period	0.0144*** (5.07)
<i>N</i>	1926

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

5 Discussion and conclusion

In this paper, we proposed an experiment that allows for testing the effects of signing a declaration and priming on increasing pro-environmental decision making. There are two main differences between these two instruments. First, signing a declaration explicitly commits the person who chooses to sign into acting in a sustainable manner while priming is implicit. Second, a person is free to choose to sign a declaration, hence “prime herself” or not while priming happens without the person’s awareness and direct consent. Our results provide evidence that presenting a declaration to sign is effective in inducing subjects to act in a sustainable manner when personal and collective interests are not aligned and there are financial incentives to make decisions that are against environmental sustainability. However, sustainability priming does not have a significant impact on subjects’ behaviour. More specifically, the treatment group where subjects were presented the option to sign a declaration had significantly, on average, lower probability of unsustainable harvesting even though more than one-third in the group did not chose to sign the declaration. We conclude that, from a public policy point of view, a declaration is an effective tool and easy to

implement by institutions aiming at fostering pro-environmental behaviour, even if not all actors will sign the declaration.

Additionally, other interesting findings emerge from our analysis. First, our results highlight the importance of peer effect in pro-environmental decisions. In our experiment, subjects observed the decisions of their two partners of the group as well as the consequence of partners' decision on one's pay-off at each period. This information might have induced subjects to "imitate" their partners who made decisions against environmental sustainability in order to increase their financial pay-off. This result can be explained the *broken windows theory* of Wilson & Kelling (1982) which shows that signs of disorder and misbehaviour in an environment encourage further disorder and misbehaviour when people can observe that others have violated a social norm. In our context, individuals seeing their peers acting in a non sustainable manner, i.e., recommending to harvest when soils sensitivity is moderate to high encouraged them to do the same. This result can also be explained by the *critical mass* model where individuals take part in an activity only if a high enough fraction of the population is engaged in this activity (Schelling, 1978). This results is also confirmed by our interaction with stakeholders at focus group meetings where it was stated by a wood buyer, for example, "I would like to follow the recommendations but difficult or costly when there are other wood buyers not following the sustainable harvest recommendations".

Second, the proportion of choices recommending to harvest increases over time tending towards equilibrium. This pattern is similar to that in repeated public good game where average contributions to the common pool decrease over time tending towards the Nash equilibrium, i.e., zero contribution to the public good (Ledyard, 1995; Fehr & Gächter, 2000; Fehr & Fischbacher, 2003; Chaudhuri, 2011). In a version of our econometric model not shown in the article, we included an interaction term between the declaration treatment and time. It was not statistically significant which indicates that the treatment effect does not disappear with time, so in both baseline and treatment of signing a declaration, time increases the probability of recommending to harvest. Third, contrary to environmental sensitivity, we do not find a significant effect of altruism on the probability of recommending to harvest. This result supports the findings of Buckley & Llerena (2018) who found that individuals who are more sensitive to environmental issues consumed

less electricity in a common pool resource game framed as an electricity consumption decision.¹⁹ However, they found no significant effect of altruism on electricity consumption choice.

Finally, as the number of wood buyers in France is not sufficiently large to constitute a sample for our study, we run our contextualized experiment with students in the laboratory. Adding a relevant context to the experimental design enhances the external validity and the applicability of the results in real-life. Moreover, considering a specific context is important for effective policy design rather than try to develop panaceas (Ostrom & Cox, 2010). A possible extension of our study would consist of running the experiment with different subject pools such as students in forest management studies and professionals in the forest sector.

¹⁹The common pool resource game concerned electricity consumption during 10 peak periods. Subjects formed groups of four where each group made up an electricity consumption system of four households.

Appendix A Priming sentences

A.1 Neutral priming

1. The desk's (book-**drawer**-boulevard) works well.
2. He is walking his (**dog**-notebook-vegetable) this morning.
3. The (pen-**customs officer**-sweeper) inspects the bag quickly.
4. He (swims-**fills out**-walks) his tax form.
5. The patient's (**bronchi**-tables-rues) are congested.
6. The child watches a happy (**cartoon**-early-cream).
7. The (**amount**-cup-bottle) requested is high.
8. His (poster-flag-**computer**) breaks down frequently.
9. The (milk-**sign**-keyboard) indicates a medieval village.
10. The (judicial-specialized-**advertisement**) posters cover the walls.
11. I'm going on a trip in (**October**-absence- top).
12. I have to (**maintain**-eat-run) the heater on a regular basis.
13. They watch a (tree-**movie**-network) at the cinema.
14. Whales live in (park-week-**oceans**).
15. He waited for his colleague on the second (sun- **floor**-choice).
16. Construction work is being (**delayed**-advice-book).
17. She thanked the (wall-parks-**volunteers**) for their participation.
18. The employees were on (hibernation-**holiday**-calling) yesterday.

19. They are going to the (speech-function-**pool**).
20. The student is looking for a (park-**book**-balloon) at the library.
21. The (**willpower**-table-street) is a thoughtful act.
22. He had a driving (total-category-**licence**).
23. The first (telephone-**goal**-market) was achieved.
24. This (speed-mountain-**procedure**) takes about two months.

Note: The words in bold presented the right answer. Subjects did not see the words in bold but in normal font.

A.2 Sustainability priming

1. (Drawing-**Recycling**-Watching) reduces the amount of waste.
2. His (poster-flag-**computer**) breaks down frequently.
3. (Sustainable-Famous-Joyful) development is everyone's responsibility.
4. The (**amount**-cup-bottle) requested is high.
5. (**Renewable**-Solidarity-Available) energy is a long term matter.
6. The child watches a happy (**cartoon**-early-cream).
7. (**Clean**-Blue-Wise) energy is affordable.
8. We must (give-**preserve**-sing) the natural heritage.
9. He (swims-**fills out**-walks) his tax form.
10. Bees are essential for (**biodiversity**-street-will)

11. Production requires natural (science-
textbfresources-activities).
12. The (pen-**customs officer**-sweeper) inspects the bag quickly.
13. Action is needed for (**climate**-telephone-possible).
14. Waste is (a calm- **an ethical**-a late) problem .
15. The patient's (**bronchi**-tables-rues) are congested.
16. We must act today for the (**future**-information-idea).
17. The (car-**ecology**-orchestra) concerns all living beings.
18. The environment is a (**public**-stationary-cultural) good.
19. The desk's (book-**drawer**-boulevard) works well.
20. The (nature-terrace-expenditure) is essential to man.
21. We must all (**respect**-draw-draw-drink) our descendants.
22. He is walking his (**dog**-notebook-vegetable) this morning.
23. Education guarantees a more (**sustainable**-fresh-sugary) world.
24. The economic and environmental (school-**balance**-team) is paramount.

Note: The words in bold presented the right answer. Subjects did not see the words in bold but in normal font.

A.3 Selected words for sustainability priming

We chose the top 15 words in bold font that are the most related to sustainability.

Word	Number of times the word was chosen
Sustainable	21
Renewable	20
Preservation	20
Biodiversity	18
Recycle	18
Common	16
Resource	16
Viable	16
Nature	14
Balance	14
Climate	14
Ethical	13
Future	13
Respect	12
Ecology	11
Clean	8
Stable	7
Green	7
Dynamic	6
Reliable	5
Innovation	5
Integrity	4
Organic	3
Wind turbine	3
Pure	3
Bees	3
Ocean/Sea	3
Continuous	2
Plant	2
Reserve	1
Equity	0

Appendix B GEB questionnaire

1. I use energy-efficient bulbs.
2. If I am offered a plastic bag in a store, I take it.
3. I kill insects with a chemical insecticide.
4. I collect and recycle used paper.
5. When I do outdoor sports/activities, I stay within the allowed areas.
6. I wait until I have a full load before doing my laundry.
7. I use a cleaner made especially for bathrooms, rather than an all-purpose cleaner.
8. I wash dirty clothes without prewashing.
9. I reuse my shopping bags.
10. I use rechargeable batteries.
11. In the winter, I keep the heat on so that I do not have to wear a sweater.
12. I buy beverages in cans.
13. I bring empty bottles to a recycling bin.
14. In the winter, I leave the windows open for long periods of time to let in fresh air.
15. For longer journeys (more than 6h), I take an airplane.
16. The heater in my house is shut off late at night.
17. I buy products in refillable packages.
18. In winter, I turn down the heat when I leave my house for more than 4 hours.
19. In nearby areas, I use public transportation, ride a bike, or walk.

20. I buy clothing made from all-natural fabrics (e.g. silk, cotton, wool, or linen).
21. I prefer to shower rather than to take a bath.
22. I ride a bicycle, take public transportation, or walk to work or other.
23. I let water run until it is at the right temperature.
24. I put dead batteries in the garbage.
25. I turn the light off when I leave a room.
26. I leave the water on while brushing my teeth.
27. I turn off my computer when I'm not using it.
28. I shower/bath more than once a day.

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Figures

Fig. 1 Payoffs of wood buyers and forest owner if **soil sensitivity is moderate to high** in ECU

WB1	WB2 and WB3	Payoff of WB1	Payoffs of WB2 and WB3 (WB2, WB3)	Payoffs of FO1, FO2 and FO3 (FO1, FO2, FO3)
Harvest	WB2 & WB3 do not harvest	150	(0,0)	(0,0,0)
	WB2 harvests	100 50	(50,0) (100,0)	(0,0,0)
	WB2 & WB3 harvest	50	(50,50)	(0,0,0)
Not to harvest	WB2 & WB3 do not harvest	0	(0,0)	(50,50,50)
	WB2 harvests	0	(150,0)	(0,0,0)
	WB2 & WB3 harvest	0	(100,50)	(0,0,0)

Fig. 2 Payoffs of wood buyers and forest owner if **soil sensitivity is low** in ECU

WB1	WB2 and WB3	Payoff of WB1	Payoffs of WB2 and WB3 (WB2, WB3)	Payoffs of FO1, FO2 and FO3 (FO1, FO2, FO3)
Harvest	WB2 & WB3 do not harvest	150	(0,0)	(100,100,100)
	WB2 harvests	100 50	(50,0) (100,0)	(100,100,100)
	WB2 & WB3 harvest	50	(50,50)	(100,100,100)
Not to harvest	WB2 & WB3 do not harvest	0	(0,0)	(50,50,50)
	WB2 harvests	0	(150,0)	(100,100,100)
	WB2 & WB3 harvest	0	(100,50)	(100,100,100)

Fig. 3 Declaration

I commit to make recommendations consistent with sustainable harvesting practices throughout the game.

☐Yes☐No

Signature

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Fig. 4 The share of subjects who recommened to harvest when soil sensitivity is moderate to high

