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Research article

# Effect of information intervention on enhancing the public payment scheme for agricultural plastic waste management

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ABSTRACT

Information intervention has been verified to be effective in influencing individual behavior. Thus, can information intervention reverse the common discrepancy of high intention but poor action among the public about participating in environmental management? Clarifying the issue is critical to facilitating the public payment scheme for agricultural plastic waste management (APWM) to evolve from idea to reality, as well as harnessing potential contributions from the public to promote the sustainability of APWM. In light of these inquiries, the study seeks to reinforce the public's payment for APWM by employing an information strategy based on the Theory of Planned Behavior (TPB) and to verify the effect of information intervention on the respondents' willingness to pay (WTP) by a randomized controlled trial (RCT). Results showed that the public's WTP for APWM is generally malleable, with information targeting normative beliefs and control beliefs significantly increasing the WTP by CNY 307.2 and CNY 400.5, respectively. Findings imply that the public payment scheme for APWM is characterized by the high perception but weak social norm and lack of effective mechanism. Consequently, it is imperative to prioritize strengthening relevant norm and constructing public payment mechanism, thereby promoting multi-entity cooperation to enhance the APWM in sustainability.

## 1. Introduction

The Sustainable Development Goals (SDGs)[1] map out the direction toward "the future we want" with a balance between human welfare and environmental sustainability (Sachs, 2012). Agricultural plastic waste management (APWM) contributes greatly to reducing the risk posed by agricultural plastic waste (APW) to environment sustainability, food safety, and human health (Rillig and Lehmann, 2020). Therefore, it is a significant driver of SDGs, especially toward SDG-2: Zero Hunger, SDG-3: Good Health and Well-being, and SDG-13: Climate Action (UN, 2015). As the world's largest producer and consumer of agricultural plastics (FAO, 2021), China attach great emphasis on APWM. It is ranked as one of the five-pronged approaches for agriculture green development, which is the pivotal initiative to promote non-point pollution prevention and control and to establish a sustained mechanism for high-quality development in the agricultural sector.

Currently, the APWM operates on the government subsidy and market operation model, which proves economically challenging for enterprises and their normal operations heavily rely on government subsidies. Taking mechanical recycling, currently the most economical and prevalent mulch film recycling technologies (Gopinath et al., 2020) as an example, a total investment of CNY 11.85 billion is required to attain the targeted recycling rate of 80% in 2021 (Appendix, A1). If entirely borne by the government, the deficit would occupy 0.5% of the total public budget expenditure allocated to energy conservation and environmental protection (MOF, 2023), imposing a considerable financial burden on the government. Furthermore, anticipated in the long run, with the end of the APW recycling pilot demonstration and the

*Abbreviations:* APWM, agricultural plastic waste management; TPB, theory of planned behavior; WTP, willingness to pay; RCT, randomized controlled trial; SDGs, sustainable development goals; APW, agricultural plastic waste; DCF, donation-based crowdfunding; KAP, knowledge-attitude-practice; COM-B, Capability-Opportunity-Motivation-Behavior; BBBF, Behavioral Barrier-Based Framework; DID, difference-in-difference; EPR, extended producer responsibility.

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downslope in government subsidies, it is inevitable for APWM to encounter the funding gap (Zhang et al., 2019, 2020). In 2020, the Chinese government issued the Guiding Opinions on Building the Modern Environmental Governance System, aiming to establish a collaborative environmental governance system in which the government plays a leading role, enterprises act as the primary agents, and social organizations and the public actively cooperate (The General Office of the CPC Central Committee and The General Office of the State Council, 2020). As the crucial stakeholder, the public's participation in environmental management has been confirmed as necessary and logical in public management theories (Ostrom, 1999, 2010). The feasibility of public payment for APWM has also been validated in previous study (Hao et al., 2023). Based on this premise, exploring effective strategies to harness individual efforts and incentivize broad public participation in APWM has become a critical direction for advancing APWM in sustainability.

However, public participation in environmental management typically exhibits the characteristics of positive attitude, moderate willingness, and low engagement (PRCEEC, 2020; PRCEEC, 2021). According to the Citizen Environmental Behavior Survey in 31 Chinese provinces, 95.9% of the 72,163 respondents demonstrated a rational understanding and favorable attitude of environmental protection actions, 79.7% expressed a willingness to contribute to environmental protection efforts, yet only 55.1% reported having participated in such activities (PRCEEC, 2021). Deviations between individual attitude, intentions and behaviors are primarily attributed to individual decision-making biases triggered by insufficient information (PRCEEC, 2020; PRCEEC, 2021). Information intervention serve as a common strategy aimed at altering individuals' perceptions, intentions, and behaviors by providing information addressing deficiencies in individuals' cognition, norms, and capabilities (Bamberg and Schmidt, 2003; Nisa et al., 2019). Information dissemination activities like education and public campaigns can enhance individuals' environmental awareness, boost confidence in the effectiveness of environmental management, foster a social atmosphere that encourages everyone participation in environmental protection, disseminate effective mechanisms and channels for such involvement, and thus positively influence a rang of environmentally responsible behaviors (Lacroix, 2018; Wang et al., 2018). As a typical environmental behavior, public participation in APWM remains in its nascent stage, with limited public awareness and a lack of established mechanisms for participation. Therefore, it will be highly beneficial for promoting a more sustainable APWM to investigate the impact of information interventions on the public's willingness to engage in APWM, and scientifically leverage information strategies to garner broader public financial support for APWM.

In summary, public participation is not only a practical necessity for advancing sustainable APWM but also an insightful exploration in the development of a modernized environmental management system. As a strategy capable of broadly enhancing individuals' willingness and actions to engage in environmental behaviors, information intervention offers a promising avenue for exploring whether and how it can promote the public payment scheme for APWM. However, there is a scarcity of research focused on the role of information intervention in public participation in agricultural white pollution. Additionally, existing studies have yet to reach a consensus on the mechanisms through which information interventions influence behavior. The primary contributions of the study lies in addressing thee following unresolved questions: Q1: Is information intervention effective in increasing respondents' WTP for APWM? Q2: If the answer to Q1 is YES, how does information take effect in this matter? Q3: What enlightenment does the intervention provide for scheme initiators or policymakers to enhance the public payment scheme for APWM? By addressing the these research questions, the research seeks to shed light on the motivated mechanism for promoting the public to pay for APWM, thereby offering strategic insights to facilitate the public payment scheme evolving from idea to reality.

## 2. Literature review

Based on the three research questions proposed in the study, the literature review focuses on three key areas: (1) public payment for waste management initiatives, (2) the impact of information interventions on individual behavioral intentions and behaviors, and (3) the application of behavioral theories in information intervention.

As a crucial actor, the public has garnered considerable attention from academia regarding its role in pollution management. Research has primarily focused on public payment for pollution management, with particular attention paid to domestic solid waste (Benyam et al., 2020; Chen et al., 2021; Liang et al., 2021; Schuermann and Woo, 2022; Yang et al., 2021), electronic and electrical waste (Afroz et al., 2013; Islam et al., 2016), construction waste (Li et al., 2018; Véliz et al., 2022; Wang et al., 2019b) and other waste that are relevant to the public. Basically, such studies revealed that people were generally inclined to pay for waste management. Besides, with the increasing severity of plastic pollution in recent years, studies investigating public payment for plastic waste management have gradually emerged. These studies typically assess respondents' willingness to contribute financially to these efforts (Abate et al., 2020; Borriello and Rose, 2022; Brouwer et al., 2017; Choi and Lee, 2018; Latinopoulos et al., 2018; Tyllianakis and Ferrini, 2021; Zambrano-Monserrate and Ruano, 2020). Additionally, factors influencing individuals' payment willingness have also been investigated, including demographic characteristics, such as gender, age, education, and household income; psychological characteristics, such as environmental responsibility, environmental awareness, and environmental love; and the external factors, such as experience of participation in environmental protection activities, frequency of exposure to plastic pollution and so on. It is evident that most research concentrated chiefly on marine plastic waste, while the few studies concerned about payment for agriculture-source plastic waste narrowly examined farmers' perspectives (Wang and Wang et al., 2019a,b). Despite growing evidence that land-based plastic pollution is significantly more severe than marine-based pollution (Bläsing and Amelung, 2018; Qadeer et al., 2021; Santos et al., 2021), there remains a scarcity of research examining the public's payment for APWM. Furthermore, researchers' viewpoints are mostly similar in investigating the payment willingness and identifying the influencing factors. While these studies offer valuable insights, a more pressing research focus involves identifying the incentive mechanisms that could enhance the public's WTP and uncovering the potential obstacles that may hinder it. Addressing this gap is crucial for advancing sustainable pollution management from the perspective of public payment, yet this remains a notable knowledge gap in the current research.

Information intervention is a commonly used strategy for behavior change (Verplanken and Wood, 2006). From the theoretical perspective, according to rational choice theory, information is the prerequisite for behavior (Edwards, 1954). Acquiring fresh knowledge can alter individuals' cognition and subsequently lead to changes in their actions (Lorenzoni et al., 2007). Similarly, the knowledge-attitude-practice (KAP) model also posits that the basis for behavioral decision-making is belief formation driven by information accumulation (Salazar et al., 2022). Information interventions leverage initiatives such as education, persuasion, training, and role modeling to convey targeted information and knowledge, reduce information asymmetry, and correct biases, thereby influencing individual decisions and steering behavior in the desired direction (Brown et al., 2017; Geng et al., 2016; Wei et al., 2020). From the empirical perspective, the impact of information intervention on behavioral intention and behavior has been widely validated. For instance, Wharton er al (Wharton et al., 2021). performed an information intervention experiment significantly improved individuals' attitudes, subjective norms, perceived behavioral control, and intentions regarding food waste, which effectively reduced household food waste. Ling et al. (2023) employed a longitudinal field experiment verified that social norms messaging about household recycling yielded

significant positive effects on recycling behavior and public support for waste prevention and harmless disposal policies. Similar conclusions have been drawn regarding green consumption (Filippini et al., 2021), energy consumption (Andor and Fels, 2018), and other environmental behaviors. Moreover, the influence of information intervention on individuals' willingness to pay for pro-environmental behaviors has also been confirmed. For example, Wei et al. (2020) carried out a survey of 1381 residents on carbon consumption demonstrated that conveying information related to low-carbon values, cultural norms, and social expectations helped enhance public capability and willingness to pay for low-carbon initiatives. Su et al. (Su and Li, 2024) investigated the effect of information intervention on consumer choices through an online survey and found that both gain and loss-framed information effectively increased consumers' willingness to pay a premium for pro-environmental hotels. Jiang et al. (2023) explored the importance of information intervention on public participation in air quality improvement by a deliberative choice experiment, and results revealed that the public exhibited a stronger willingness to improve air quality with more environmental information, with WTP increasing by CNY 35.2 to CNY 46.8.

Current research on information interventions predominantly emphasizes the development and validation of various types of interventions, often overlooking the antecedents and pathways that drive changes in behavioral intentions and behaviors. For instance, Grilli et al. (Grilli and Curtis, 2021) reviewed the methods and approaches encouraging pro-environmental behaviors and identified five types of treatments: education and awareness, outreach and relationship building, social influence, nudges and behavioral insights and incentives. Nemati et al. (Nemati and Penn, 2020) conducted a meta-analysis of information-based interventions for environmental behaviors, revealing that information based on consumption feedback, environmental prompts, and community comparisons effectively reduced residential customers' consumption of electricity, gas, and water. While these types of information strategies undoubtedly have a broad impact on manipulating individual behavior towards desired outcomes, the researches lack systematic examination in terms of the antecedents and pathways why behavioral intention and behavior change. This gap prevents a detailed understanding of how information strategies function in behavior change processes, which is crucial for policymakers in designing targeted information interventions. In this regard, Michie et al. and Uehara et al. have contributed meaningful improvements to the study of behavior interventions. Specifically, Michie et al., 2011, 2014 introduced the Behavior Change Wheel, utilizing the Capability-Opportunity-Motivation-Behavior (COM-B) model to attribute behavior changes induced by different types of interventions to alterations in capability, opportunity, and motivation, thus providing valuable guidance for the design of behavioral interventions. Through the development of the Behavioral Barrier-Based Framework (BBBF), Uehara et al. (Allison et al., 2022) offered a clear approach for policymakers on how to select appropriate interventions from a multitude of options by setting policy targets, identifying desirable behavioral changes, identifying critical barriers, and selecting suitable intervention measures. Despite these advances, existing studies remain focused on qualitative analysis and have yet to conduct comprehensive empirical examinations. Such empirical research is necessary to validate the specific antecedents and pathways through which informational interventions exert their influence, providing a scientific basis for the design of evidence-based informational strategies for policymakers.

Leveraging behavioral theory to categorize information can unveil the mechanisms through which information interventions influence individuals' payment decisions for APWM (Kwasnicka et al., 2016). As one of the most extensively applied theories in individual behavior research, the Theory of Planned Behavior (TPB) provides a robust theoretical framework for designing behavior interventions (Steinmetz et al., 2016). Research has demonstrated that TPB is among the most effective models for developing interventions aimed at environmental behaviors (Yuriev et al., 2020) and has been shown effective in explaining the public's payment for APWM (Hao et al., 2023). According to TPB, payment intentions are jointly determined by attitudes, subjective norms, and perceived behavioral control (Fig. 1) (Ajzen, 1991). Among them, attitudes reflect individuals' positive or negative evaluations of conducting APWM. Subjective norms describe perceived social pressure when paying or not, which is determined by the reference groups' approval and implementation of the payment. Perceived behavioral control refers to the degree of difficulty individuals perceive in paying for APWM, specifically relating to the payment's accessibility, affordability and expected outcomes. TPB states that beliefs are antecedents of behavioral intentions. Interventions can introduce new salient beliefs or make existing beliefs more salient, triggering changes in attitudes, subjective norms and perceived behavioral control, thereby leading to a transformation in individuals' behavioral intentions and behaviors (Ajzen and Fishbein, 1980). More precisely, interventions can effectively influence payment by modifying individuals' beliefs about positive or negative evaluations of APWM, their perceived social pressure of paying or not, and their sense of control and efficacy to pay.

Based on the above analysis, the study aims to shed light on the motivated mechanism for promoting the public to pay for APWM through information intervention, thereby bringing insights into developing strategies to facilitate the public payment scheme evolving from idea to reality. Specifically, grounded in the TPB framework, the study designs interventions targeting different belief structures and conducts a randomized controlled trial. By exposing various groups to distinct informational treatments, the trial seeks to differentiate the effects of belief-based information. The objective of the study is to determine whether information interventions can influence public willingness to pay for APWM and to elucidate the pathways through which these interventions exert their effects. The findings of the study can not only validate the effectiveness of information strategies in enhancing public willingness to pay for APWM but also clarify the pathways through which these information function. This understanding will contribute to revealing the incentive mechanism that promote public payment and thus providing critical insights for the implementation of APWM public payment scheme.

## 3. Methodology

### 3.1. Participants and survey

The study was conducted in Xinjiang, Gansu, Ningxia, and Inner Mongolia (Fig. 2). Two primary reasons underpinned the survey in this region. Firstly, the natural endowment and cropping structure in the four provinces (autonomous region) necessitate the extensive use of mulch film, leaving the region an ideal representation of research on APWM. China consumes approximately 2.4 million tons of agricultural plastics annually, with over 50% attributed to mulch film (NBSC, 2023a). Given the usage amount, product performance, application scenarios, and management practices across different types of agricultural plastics, the management of mulch film waste represents the most complex within agricultural plastic management (Beriot and Huerta-Lwanga, 2023; Cai et al., 2024), representing significant practical research value. Approximately 30% of farmland in the region is covered by mulch film, far exceeding the national average of 13.7% (NBSC, 2023a; NBSC, 2023b). In 2022, 506 thousand tons of mulch film were used in the region, accounting for over one-third of the total in China (NBSC, 2023a). The average usage intensity was twice the nationwide average at 21 kg/ha (NBSC, 2023a). Mulch film is intensely utilized in the region, and APW status here is the severest in China, giving rise to a high level of APWM urgency. Secondly, samples within the same geographic location are relatively homogeneous, minimizing the interference of confounding factors. The four provinces (autonomous region) surveyed are in northwest China and characterized by comparable demographic characteristics, such as the population's

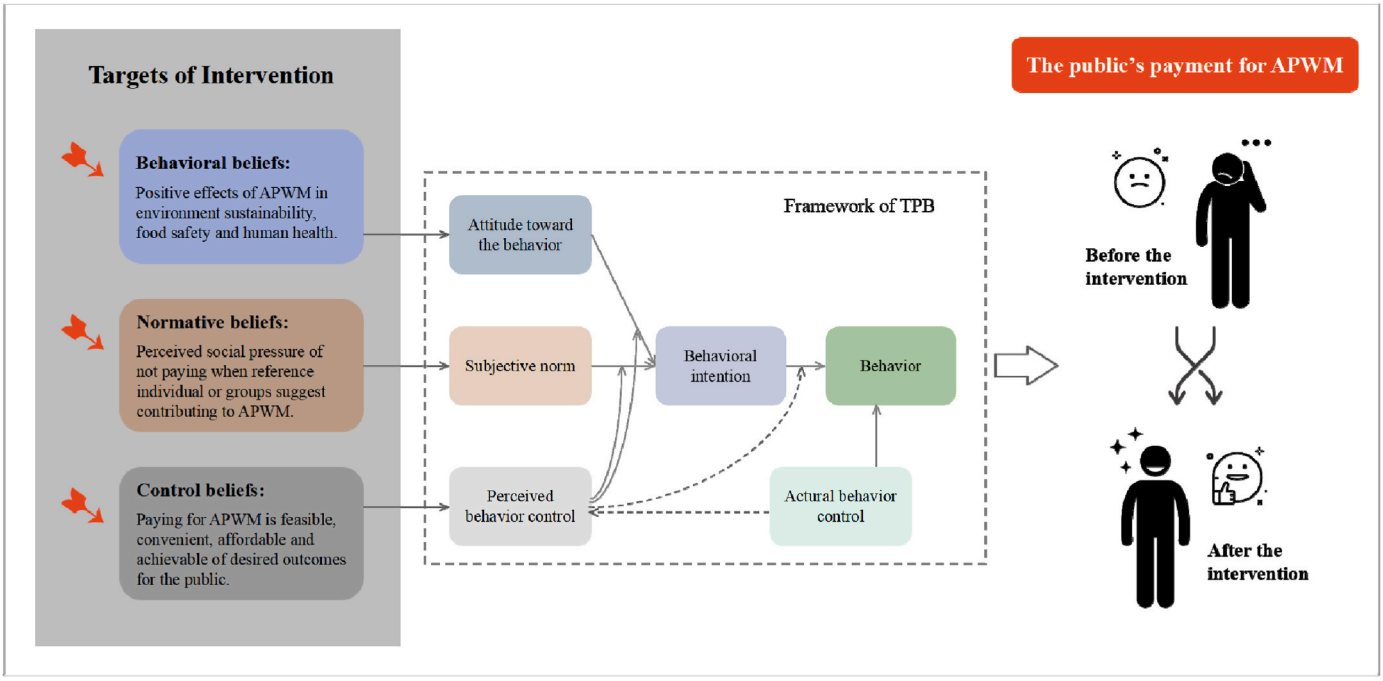


**Fig. 1.** Targets of information intervention based on TPB framework.

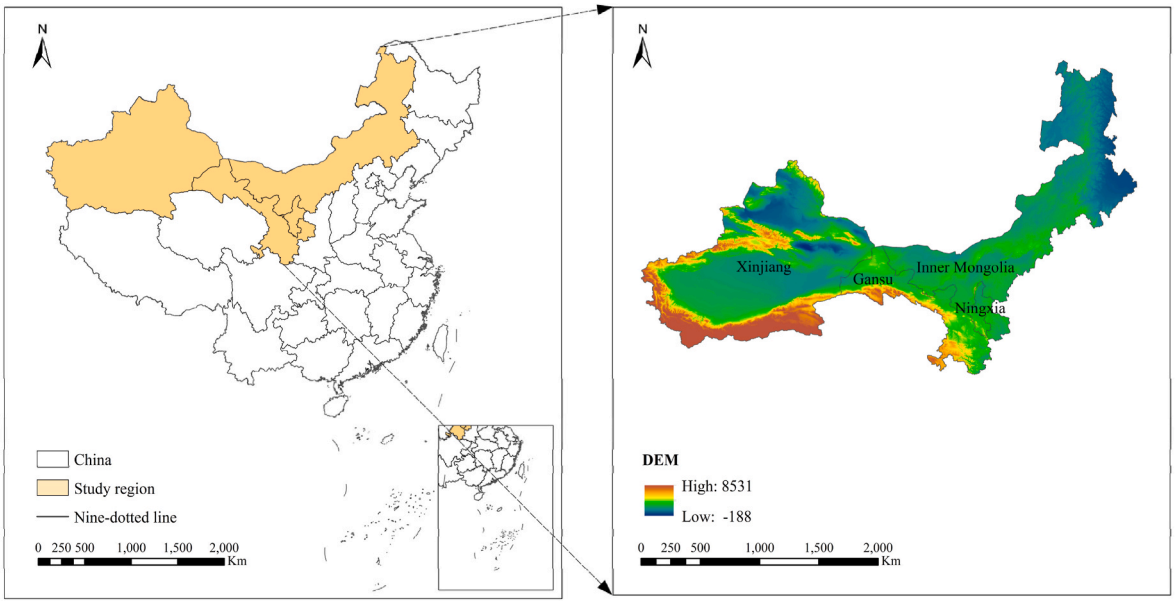


**Fig. 2.** Study region.

urban-rural ratio, education level, and household economic condition.

The study employed the online survey approach. Public payment for APWM is comparable to crowdfunding, generally facilitated through dedicated websites or social applications (Stanko and Henard, 2017). Online surveys also boast the benefits of accommodating broad target audiences, being cost-effective, and generating timely responses (Ghobadi, 2022). Questionnaire Star (https://www.wjx.cn/), China's most prominent online survey platform with over 300 million active users, was commissioned to survey in June and July 2022. Questionnaires were distributed on a large scale via online distribution to individuals residing in the study region. The feedback was administered via Cloud Research, which comes with the platform. From the initial pool of 1405 questionnaires, 1288 valid responses were identified after excluding low-quality submissions. The effective response rate is 91.7%. According to Huang et al. (2019), the required sample size was determined. The minimum sample size for the study region, which has a population of 82.1 million (NBSC, 2023b), is calculated to be 664 with a margin of error of 5% and a confidence level of 99%, confirming that the sample size in the study is sufficient. A prior analysis was conducted applying G.Power (version 3.1.9.7) to determine the minimum sample size necessary for each group. Assuming a medium-small effect size ($d = 0.25$) and 80% efficacy (Prelez et al., 2023), the sample size was estimated to be 253. The sample size for each group in the study satisfies the requirement.

Table 1 briefly summarizes the individual and household characteristics of the 1288 respondents. Overall, the sample reasonably

**Table 1**
Demographic characteristics of respondents.

| Characteristics | | Frequency | Percent | Characteristics | | Frequency | Percent |
|---|---|---|---|---|---|---|---|
| Gender | | | | Marital status | | | |
| | Male | 611 | 47.4 | | Unmarried | 589 | 45.7 |
| | Female | 677 | 52.6 | | Married | 699 | 54.3 |
| Age | | | | Number of household | | | |
| | < 18 | 95 | 7.4 | | < 3 | 45 | 3.5 |
| | 18–29 | 629 | 48.8 | | 3–5 | 1032 | 80.1 |
| | 30–39 | 367 | 28.5 | | 6–8 | 207 | 16.1 |
| | 40–49 | 136 | 10.6 | | > 8 | 28 | 2.2 |
| | > 49 | 61 | 4.7 | Number of teenager | | | |
| Place of residence | | | | | < 3 | 1232 | 95.7 |
| | Urban | 560 | 43.5 | | 3–4 | 56 | 4.3 |
| | Rural | 728 | 56.5 | Number of the elderly | | | |
| Health status | | | | | < 3 | 1244 | 96.6 |
| | Bad | 12 | 0.9 | | 3–4 | 44 | 3.4 |
| | Not very good | 24 | 1.9 | Household annual income (CNY) | | | |
| | Just OK | 255 | 19.8 | | < 10,000 | 105 | 8.2 |
| | Good | 624 | 48.4 | | 10,000–29999 | 127 | 9.9 |
| | Very Good | 373 | 29.0 | | 30,000–69999 | 268 | 20.8 |
| Education level | | | | | 70,000–129999 | 328 | 25.5 |
| | Primary school | 42 | 3.3 | | 130,000–209999 | 318 | 24.7 |
| | Junior high | 141 | 10.9 | | 210,000–310000 | 100 | 7.8 |
| | Senior high | 201 | 15.6 | | > 310,000 | 42 | 3.3 |
| | College | 822 | 63.8 | | | | |
| | Postgraduate | 82 | 6.4 | | | | |

represents the population in the study region. Respondents were evenly distributed by gender (male v.s. female = 47.4% v.s. 52.6%), marital status (married v.s. unmarried = 54.3% v.s. 45.7%), and place of residence (urban v.s. rural = 43.5% v.s. 56.5%). The respondents generally being in relatively good health. However, it should be acknowledged that the sample may slightly over-represent the young and educated population, especially those between 18 and 39 years old and with a high school or college education. This observation aligns with research on online surveys (Couper, 2000; Sterrett et al., 2017). Meanwhile, household size and income are generally consistent with those reported in the China Statistical Yearbook (NBSC, 2023b).

### 3.2. Experiment design and procedure

The impact of information intervention was evaluated employing the RCT approach, wherein changes in the respondents' WTP for APWM between various treatment groups before and after the intervention were compared with those of the control group. Specifically, Q1, whether the information intervention affects the public's WTP for APWM, can be addressed by examining whether respondents' WTP changed before and after the information intervention. By assessing the degree of changes in respondents' WTP for APWM in different treatment groups compared with the control group after information intervention, Q2, the mechanism by which information affects the public's WTP for APWM, can be answered. Finally, incorporating the answers to Q1 and Q2, the motivated mechanism of the public payment scheme for APWM and enlightenment to promote the scheme, i.e., Q3, will be clarified.

Fig. 3 exhibits the process of the RCT. After a brief introduction to the purpose of the questionnaire and obtaining consent, respondents' demographic characteristics were collected, and their WTP for APWM was pretested. WTP was quantified on an open-ended format by the maximum amount respondents were willing to pay annually on a household basis. Afterward, participants were randomly assigned to different groups. Randomization is necessary for the study to guarantee no systematic differences among the groups other than the intervention, which was achieved by the automated assignment process embedded in the Questionnaire Star platform. 1288 participants were randomly assigned to one of five groups. One group functioned as the control and received only a piece of brief information. Four treatment groups were exposed respectively to information about specific belief categories in

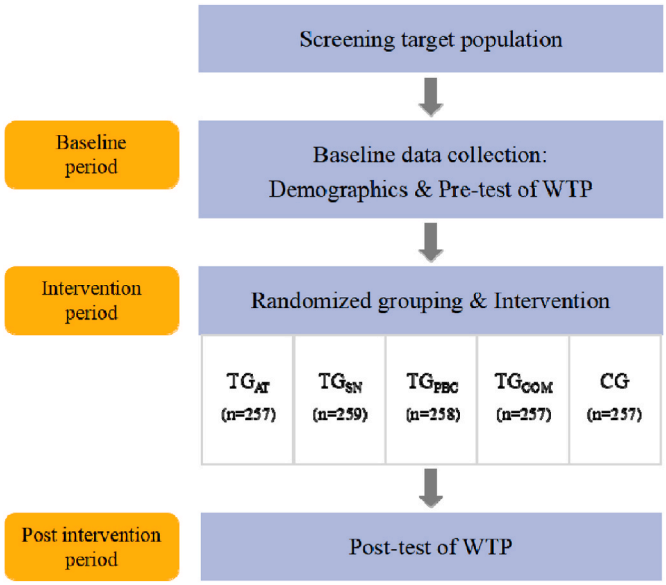


**Fig. 3.** Flowchart of randomized controlled trial.

the TPB displayed in Fig. 1. $TG_{AT}$ provided participants with information targeting behavioral beliefs related to paying for APWM. $TG_{SN}$ presented information about normative beliefs concerning the payment. $TG_{PBC}$ offered information that could reinforce payment control beliefs. Participants in $TG_{COM}$ received the combined-belief information mentioned above. Table 2 outlines the detailed information provided to each group. After the information intervention, respondents were re-surveyed on their WTP in a post-test format. The study was a rigorous double-blind trial to avoid biased results by the placebo effect or observer-expectancy effect (Angrist and Pischke, 2010).

### 3.3. Analysis methods

The Difference-in-Difference (DID) model assessed the effect of information intervention by employing Stata 16. DID compares discrepancies in participants' WTP before and after the intervention between

**Table 2**
Experiment design and information description.

| Objected variable | General information | AT | SN | PBC |
|---|---|---|---|---|
| Targeting beliefs | None | Behavioral beliefs: APWM can mitigate agricultural non-point pollution and reduce the potential environment sustainability, food safety and human health threats posed by APW. | Normative beliefs: When reference people and groups, such as relatives, friends, communities and the government suggest paying for APWM, individuals are likely to show a positive payment willingness to avoid social pressure. | Control beliefs: If individuals perceive a sense of control over the payment, including knowing how to pay for APWM conveniently, anticipating with no financial burden, and believing their payment will bring about better APWM, they will feel more confident and enthusiastic about paying for APWM. |
| Detailed information | China is the largest agricultural plastics consumer in the world. Agricultural plastic waste refers to post-consumed mulch film, greenhouse film, pesticide and fertilizer packaging, irrigation pipes and so on. Currently, agricultural plastic waste, especially mulch film waste, is mismanaged, resulting in widespread farmland white pollution. | Robust evidence has shown that APW will damage crop yields and quality in the long term if discarded on farmland. Plastic residues can break down over time into microplastics, spreading in terrestrial, aquatic and atmosphere systems. Microplastic may enter the food chain and thus threaten human health. APW can be disposed of by open burning, landfill and recycling. Among them, recycling is the best management practice for not only solving environmental pollution and health threats but also turning waste into resources. | According to our nationwide survey of different individuals, and groups companies, the majority are willing to make their contributions to APWM for better tackling the problems caused by APW. Managers from government organizations, scientific institutes, media and companies will take the lead to donate and call on everyone who cares about the environment and health to join together.<br>Let's participate in and donate to APWM together, help keep farmland clean and express our sense of responsibility and mission. | With government permission and regulation, relevant charity organizations are setting up an APWM Fund to effectively and sustainably mitigate agricultural white pollution. Through access to WeChat, Weibo, Alipay and other applications, the public can make voluntary donations to the fund in a convenient manner. The government and charity organizations will monitor the use of the funds, ensure the effectiveness of APWM, and regularly and truthfully disclose relevant information to society. Little giving, large gains, every coin you donate will help create cleaner farmland. |
| $TG_{AT}$ | ✓ | ✓ | | |
| $TG_{SN}$ | ✓ | | ✓ | |
| $TG_{PBC}$ | ✓ | | | ✓ |
| $TG_{COM}$ | ✓ | ✓ | ✓ | ✓ |
| CG | ✓ | | | |

treatment and control groups. With the DID model, unobservable factors that affect the changes in WTP can be excluded, allowing the net effect of the intervention on these changes to be identified. The DID model is presented as follows:

$$WTP_{it} = \alpha + \beta Post_t \times Treat_i + \gamma X + \varepsilon_{it}$$

where $WTP_{it}$ denotes the WTP for the APWM of individual i in time t. $Post_t$ is a dummy variable, which equals to 1 if after the information intervention, otherwise 0; $Treat_i$ is also a dummy variable, which equals to 1 if individual i laid in the treatment group, otherwise 0. $X$ represents a set of covariates, which includes respondent's gender, age, place of residence, education level, marital status, household size and income. $\varepsilon_{it}$ is an error item. $\beta$, the coefficient on the interaction term of $Post_t \times Treat_i$, measures the impact of information intervention on individuals' WTP, that is, the intervention efficacy. A positive estimate of $\beta$ indicates an increase of WTP by information intervention and vice versa.

DID tests the null hypothesis that the changes in WTP are attributed to information intervention. There are three critical requirements for a DID analysis to yield internal validity for such a hypothesis test, which include i) the assignment of treatment and control group is independent of the baseline levels; ii) there is no spillover effect between treatment and control groups; iii) baseline levels of both groups feature parallel trends before the intervention implementation (Angrist and Pischke, 2009). Completely randomized assignment to the treatment and control group caters to requirement i), and the mutual independence between treatment and control groups guarantees requirement ii). Requirement iii) would be proved validated in 4.1.

**Table 3**
The statistics of the Kruskal-Wallis and Pearson Chi-Square Tests.

| | Estimae | | df | Sig. |
|---|---|---|---|---|
| | Kruskal-Wallis H (K) | Pearson Chi-Square | | |
| Age | 4.042 | / | 4 | 0.400 |
| Health status | 8.272 | / | 4 | 0.082 |
| Education level | 1.541 | / | 4 | 0.819 |
| Number of household | 3.147 | / | 4 | 0.534 |
| Number of teenager | 3.481 | / | 4 | 0.481 |
| Number of the elderly | 4.007 | / | 4 | 0.405 |
| Household annual income | 3.789 | / | 4 | 0.435 |
| Gender | / | 1.173 | 4 | 0.883 |
| Place of residence | / | 1.259 | 4 | 0.868 |
| Marital status | / | 3.085 | 4 | 0.544 |

Note: The statistical significance is determined on 5% significance level by a two-tailed test.

## 4. Results

### 4.1. Baseline analysis

Demographic characteristics of the respondents from different groups were initially compared to ascertain the validity of randomization. Age, education level, and other continuous variables were examined using Kruskal-Wallis H non-parametric tests to determine whether there were significant differences among various groups. Chi-Square tests were then employed to check categorical variables, such as gender, place of residence, and marital status. Table 3 indicates that there were no significant differences between the covariates among the five groups, thus ensuring that there were no systematic differences across groups. The result validates requirement iii).

### 4.2. Efficacy of information intervention

Table 4 and Fig. 4 illustrate the WTP of respondents for APWM across each group, both pretest and posttest. Compared to the pretest, the WTP in the four treatment groups increased to varying degrees in the posttest.

**Table 4**
The estimation of WTP in different groups.

| | All sample | | $TG_{AT}$ | | $TG_{SN}$ | | $TG_{PBC}$ | | $TG_{COM}$ | | CG | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pretest | posttest | pretest | posttest | pretest | posttest | pretest | posttest | pretest | posttest | pretest | posttest |
| Observation | 1288 | | 257 | | 259 | | 258 | | 257 | | 257 | |
| Mean (CNY) | 482.6 | 708.6 | 430.6 | 560.7 | 408.6 | 653 | 394.1 | 731.8 | 458.9 | 938.9 | 721.5 | 658.7 |
| Std. Dev. | 812.32 | 1292.61 | 488.42 | 678.94 | 463.34 | 1171.52 | 555.38 | 1481.45 | 573.68 | 1588.26 | 1466.18 | 1322.3 |

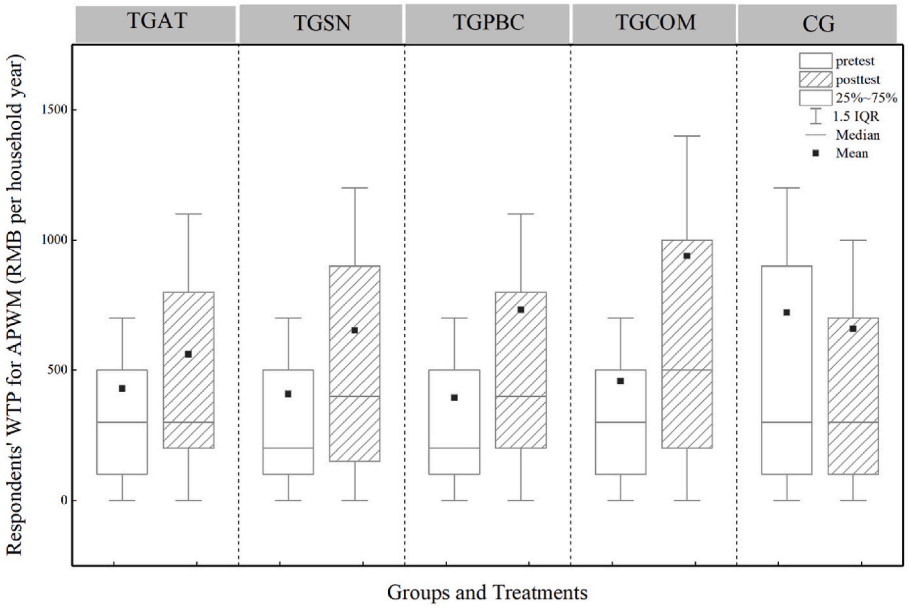


**Fig. 4.** Boxplot of WTP by experiment period for treatment groups and the control group.

**Table 5**
Efficacy of information intervention in WTP for APWM.

| Variables | DID between $TG_{AT}$ and CG | DID between $TG_{SN}$ and CG | DID between $TG_{PBC}$ and CG | DID between $TG_{COM}$ and CG |
|---|---|---|---|---|
| Treat × Time | 192.88 | 307.23** | 400.45*** | 542.75*** |
| | (128.67) | (139.29) | (152.88) | (154.80) |
| Constant | 1255.57*** | 1300.15** | 1436.91** | 1051.64* |
| | (443.19) | (653.92) | (557.56) | (600.75) |
| Controls | Yes | Yes | Yes | Yes |
| Observations | 514 | 516 | 515 | 514 |
| Adj R-squared | 0.0815 | 0.0929 | 0.0677 | 0.1006 |

Note: Treat × Post is an interaction term of treatment dummy and time dummy variable. Standard Errors are estimated by linear regression and shown in parentheses, and statistical significance of the two-sided t-tests that regression coefficients differ from zero are indicated as: ***$p < 0.01$; **$p < 0.05$; *$p < 0.1$.

Information intervention enhanced the respondents' WTP both economically and statistically (Greene, 2017), indicating the answer to Q1 is YES. In contrast, it declined for the control group, which may stem from the anchoring effects where respondents were more rational and more prudent toward their reported WTP (Simonson and Drolet, 2004). Table 5 summarizes the regression results for the impact of information intervention on WTP. The interaction term coefficient for *$TG_{SN}$ v.s. CG* was 307.23 and significant at a 5% statistical level, indicating an increase of CNY 307.23 in WTP for respondents in $TG_{SN}$ after the intervention compared to the control group. Similarly, the interaction terms coefficients for *$TG_{PBC}$ v.s. CG* and *$TG_{COM}$ v.s. CG* were 400.45 and 542.75, respectively, and were both significant at a 1% statistical level. In contrast, the coefficient for *$TG_{AT}$ v.s. CG* did not show significant result. The results demonstrated that control beliefs have the most decisive influence on the public's WTP, followed by normative beliefs, while the impact of behavioral beliefs on WTP was less pronounced. It yielded the answer to Q2 that information primarily affected the public's WTP for APWM by influencing perceived behavioral control and subjective norms regarding the payment. Correspondingly, the focus of promoting the APWM public payment scheme lies in strengthening the public payment norms and establishing the public payment mechanism, revealing the answer to Q3.

## 5. Discussion and implications

The current APWM model of government subsidy and market operation in China suffers from great uncertainty. Multi-entity cooperation, represented by public participation, is an innovative solution to promote sustainable APWM. Along with an increasing demand for a cleaner environment and the growing awareness of environmental protection, the public's support holds great prospects for promoting APWM. Unlocking the public's potential requires accurately identifying the outstanding issues hindering public participation in APWM and clarifying the motivated mechanism of promoting the public to contribute. In this regard, the study investigates the salient beliefs that can influence the public's payment for APWM through a TPB-based information intervention trial. The insights gained from the study would provide theoretical evidence that can guide policymakers in developing targeted policies and promoting widespread social support toward public payment scheme for AWPM.

### *5.1. APWM public payment scheme is distinguished by high perception, weak norm and lack of mechanism*

The results indicated that providing information targeting normative

beliefs, control beliefs and combined-beliefs significantly increased respondents' WTP by CNY 307.23, 400.45 and 542.75, respectively, compared to the pre-intervention period. It presented a confirmed answer for Q1. The finding implies that there are information deficits in the public's understanding of APWM public payment scheme, and that tailored information can be delivered to increase their WTP. This observation aligns with previous research on air pollution control (Jiang et al., 2023; Urama and Hodge, 2006) and municipal waste management (Wang et al., 2021), which demonstrated that the public is universally poorly informed about contributing to public utilities and that information interventions are generally effective in enhancing their WTP for these matters. By validating the efficacy of information strategy, new financing channels may emerge to support environmental conservation initiatives that face uncertain funding landscapes. Findings pointed towards innovative avenues to overcome financial barriers for sustainable environmental programs through targeted information that inspires public engagement. Further, among the three TPB-based beliefs, control beliefs exerted the greatest influence on the public's WTP, followed by normative beliefs, while behavioral beliefs were less significant. The result highlighted the mechanism by which information intervention promoted the public's payment for APWM was primarily through strengthening social norms and enhancing their sense of control over the payment. This addressed the Q2 on how information strategies took effect, underscoring normalized social obligations and individual agency rather than shifting attitudes for the payment.

Control belief of public payment for APWM, as described in 3.2, comprises four main components: feasibility, achievability of desired outcomes, convenience, and affordability. The public payment scheme is an envisaged solution to promote APWM, and the information that confirms its feasibility can dispel the public's inner doubts (Stern et al., 2022). Secondly, following social learning theory, expected outcomes of a behavior can induce behavioral motivation (Bandura, 1986). Accordingly, emphasizing that the payment will bring about desired benefits stabilizes the public's expectations and paves the way for triggering their payment motivations. Thirdly, highlighting the convenience of paying for APWM reduces uncertainty in individual behavioral choices (Cheng et al., 2022), making payment decisions primarily depend on individual perceptions and preferences (Liobikienė and Miceikienė, 2022). Additionally, convenience can also strengthen outcome expectations and self-efficacy in performing the behavior (Aschemann-Witzel et al., 2018; Knickmeyer, 2020), indirectly facilitating payment decisions. Lastly, public payment for APWM is intrinsically a voluntary donation behavior (Belleflamme et al., 2014), featuring the voluntary principle. Underlining this principle to potential payers overcomes cognitive biases of financial burdens which may hinder such payment (Konrath and Handy, 2017).

Individuals' preferences, attitudes and behavioral choices are commonly affected by others (Becker, 1974), explicating the effectiveness of normative information. In a collective society, reference groups establish the criteria governing right and wrong behavior (Nixon et al., 2009), and individuals follow such criteria to gain social recognition (Collado et al., 2019). When others pay for APWM and expect peers to act as such, people may comply to gain approvals and a sense of social belonging (Taylor and Todd, 1995). Normative information may also work for alleviating the probable assurance problems and free-rider problems, which typically confront private provision of public goods. Individuals may decline to pay for APWM when they believe no one else will pay to save their efforts (Sen, 1967) or when they anticipate that others will pay and they can share the fruits for free (Trivers, 1971). The optimal strategy is to cooperate when others are cooperating and stop when they are not (Schmitz, 2015). Normative information dispels the suspicion that others will not cooperate, signals the social risk of not cooperating, and thus motivates individuals to make payment decisions.

The study shows that the impact of behavioral belief information is insignificant on respondents' WTP. This finding can be attributed to the widespread and continued worsening of the APW issue in China. The prevalence of APW-related news, such as "mulch film stops train incident""A credit card's worth of microplastics ingestion everyday", are evident in the media, increasing residents' perception of APW concerns. Furthermore, the government has vigorously promoted and widely publicized APWM policies, such as extended producer responsibility (EPR) system and trade-ins, in recent years. These efforts have led to farmers' increased knowledge, as well as the public's elevated awareness for APW. Post-materialism and Environmental Kuznets Curve indicate that rising income and education level accompany by a corresponding increase in environmental literacy and awareness (Grossman and Krueger, 1995). With China advancing to upper middle-income status (World Bank, 2022) and education level surpassing the average of those upper middle-income countries (NBSC, 2021; NBSC, 2022), the public has upgraded pursue for a more beautiful and cleaner living environment. Consequently, providing information aimed at raising individuals' APWM awareness offers an insignificant marginal contribution.

### *5.2. The transformation of the public's payment intention into payment action requires establishing a sound public participation system*

More than one third of respondents indicated that they were willing to pay for APWM in the study, the average WTP is CNY 482.6 per household year. Yet it is disputed to anticipate how this demonstrated payment intention will effectively convert into substantive contribution action. China Charity Alliance recorded that, nationwide donations toward environmental conservation is CNY 2.24 billion in 2019, of which one quarter originated from the public contributions (China Charity Alliance, 2020). It can be generally estimated that each person donated no more than CNY 0.4 on average, starkly unveiling the fact that the sum allocated to APWM is bound to be exceedingly restricted. There exists a vast disparity between the public's intention of contributing to environmental management and their actual acts. Despite verbal support for cooperative government policies regarding environmental management, the backing does not definitively convert to significant participation actions. This discrepancy can potentially be attributed to existing policy priorities. First explicitly proposed in the 19th National Congress of the Communist Party of China, the pressing need to "establish an environmental governance system led by the government with enterprises functioning as primary subjects and both social organizations and the public serving as participants," has accorded greater priority to public involvement in these matters. Subsequently, the government initiated two major plans in 2021, "Beautiful China, I am the Actor" and "Citizen Environmental Behavior Guidelines (Trial Implementation)". These efforts focus on elevating public consciousness toward ecological preservation and foster environmental literacy through systematic education and public outreach initiatives, so as to encourage active public involvement in environment governance. However, as the awareness increase of relevant policies and notion endorsement of public cooperation in environmental governance, the government faces an ongoing challenge to recognize emerging issues in public participation and respond with policy adjustments as necessary.

The same is true for APWM. The result reveals that the public payment scheme for APWM is obstructed by the absence of robust mechanism and weakness of social norm. Transitioning from a mere positive intention toward actual payment necessitates added momentum. The study implied the answer to Q3, which is to establish a sound public participation system, especially more conducive external circumstances and an intensified social consensus. Consequently, importance should be placed on instituting a well-structured public payment system, with a primary focus on establishing mechanism and strengthening norm, so as to subsequently facilitate the transformation of everyone is willing to pay into everyone pays.

The foundation for establishing mechanism involves the initiation of a public payment scheme for APWM which will unblock channels for public participation and enhance scheme accessibility. Priority should

be given to charitable organizations with crowdfunding qualification, who boast robust user bases and high social credibility, to act as scheme initiators and thereby securing public trust (Choy and Schlagwein, 2016). Secondly, crowdfunding platform is better integrated with social applications, so as to streamline information collection, donation transactions, and interactive communication into a standardized process, thereby increasing convenience (Choy and Schlagwein, 2016). Thirdly, a rigorous information disclosure system that is compliant with the Charity Law and relevant industry regulations, such as "Administration Measures for Public Donation Platform Services""Technical specifications for Internet fundraising information platforms for charitable organizations""Management specifications for Internet public fundraising information platforms for charitable organizations", should be developed. Factual updates regarding the progress of fundraising, spending and project implementation should be made readily available to the public via dedicated websites in a comprehensive and timely manner. Meanwhile, active interaction with donors can also serve to reduce information asymmetry and stabilize public expectations and confidence (Shen and Wang, 2023). Lastly, it is crucial to reaffirm the voluntary principle of the scheme, ensuring that contributions will not impose financial burden on potential donors.

Regarding norm strengthening, it is vital to integrate the contributions of diverse actors, which includes governments, social networks, and individuals. Most importantly, primacy should be given to authoritative entities, such as governments and esteemed environmental organizations, to leverage their persuasive performance (Liu, 2008). By endorsing the public payment scheme for APWM as one of the "Top 10 Public Participation Cases of the year", these entities can promote the formation of public payment norm (Halder et al., 2021) and encourage widespread public involvement in APWM. Secondly, given that there are approximately 4.62 billion active social media users globally (DataReportal, 2022), and the Chinese internet penetration rate stands at 75.6% (CNNIC, 2023), the internet embodies immense potential for shaping norms. Moreover, information dissemination through social networks is both interactive and capable of generating substantial emotional resonance (Yin et al., 2021). In view of this, the benefits of social network propagation should be harnessed to maximize the potential of the broad internet users and foster a social ethos of collective giving and shared governance within the expansive digital sphere. Additionally, peer-to-peer information sharing should not be overlooked (Nisar et al., 2022), due to limitations of governmental advocacy and social media opinion in exerting direct interpersonal pressure (Young et al., 2017). The government can consider recognizing individuals who make outstanding contributions to APWM with the "Most Eco-Friendly Volunteer" award. This would serve to encourage environmentally literate individuals with strong convictions to act as opinion leaders (Al-Oraiqat et al., 2022) and champion the cause by sharing the scheme within their social circles and seeking other's support (Bénabou and Tirole, 2006).

### 5.3. *Multi-entity participation is the inevitable choice for sustainable APWM*

APWM is highly sustained by financial subsidies, posing heavy burdens on the government while introducing considerable uncertainty into the matter. For a sustainable approach to APWM, it is imperative to

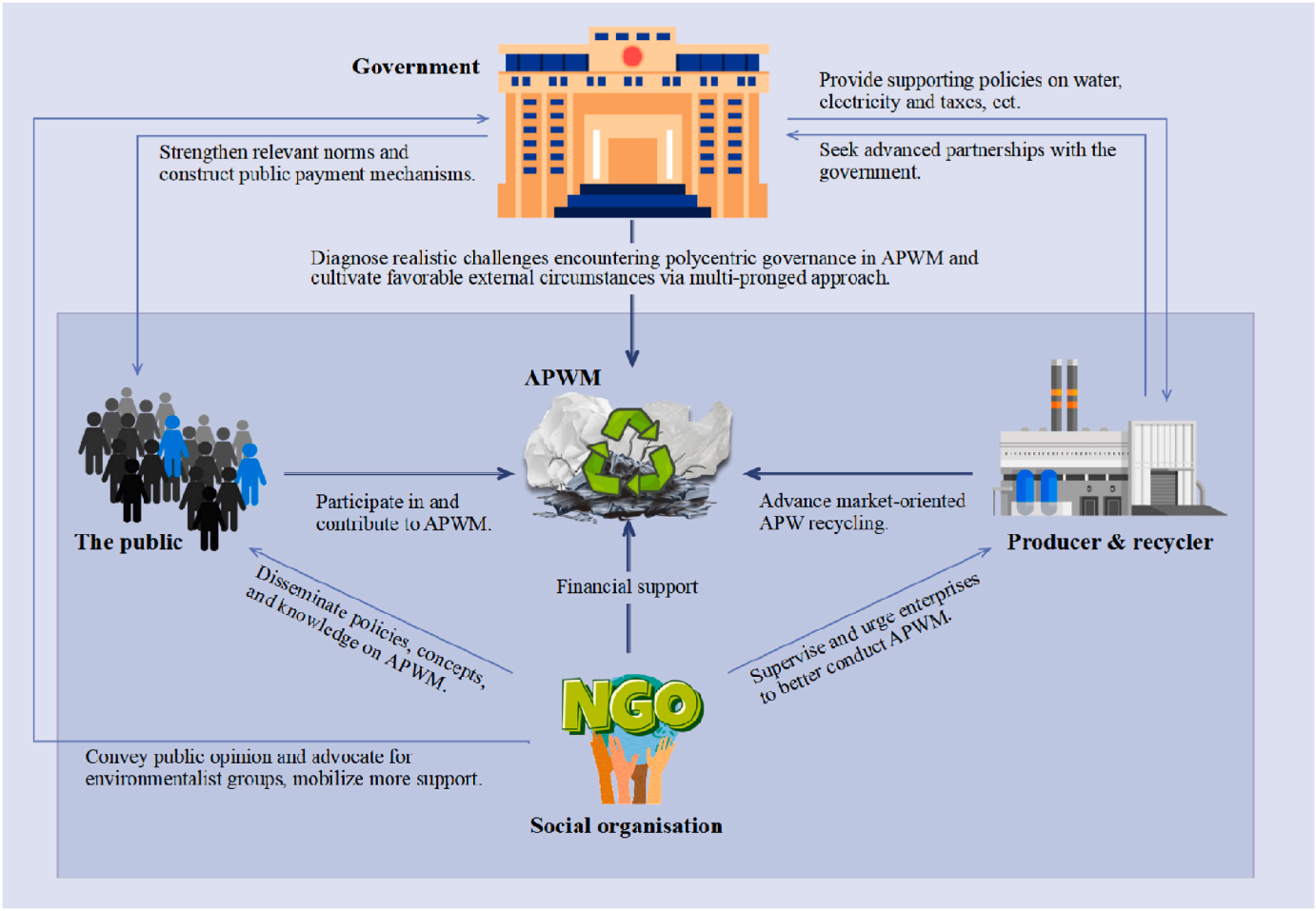


**Fig. 5.** Multi-entity cooperation in APWM.

identify innovative funding sources. The public, a crucial APWM stakeholder with three-fold identity of service recipients of agricultural plastics, victims of APW, and beneficiaries of APWM, is justified in making contributions to APWM. The study reveals that over two-thirds of the respondents exhibit positive payment willingness toward APWM after the information intervention, with an average WTP ranging from CNY 560.7 to CNY 938.9 per household year. Based on a rough estimation of a 10% environmental donation rate (China Charity Alliance, 2020), if such interventions were implemented nationwide, public payment scheme could potentially raise upwards of CNY 28 billion annually for APWM. This would significantly advance APWM and provide substantial impetus to mitigating the widespread non-point pollution resulting from APW and its historical legacies. Beyond the economic value, it's crucial to underscore that public payment scheme also delivers far-reaching social benefits of the modernization of environmental governance systems and capacities. Public payments for APWM can be viewed as fostering partnerships among governments, enterprises, social organizations, and the public, which breaking away from the traditional "government and market" governance model (Ostrom, 1999, 2010). It has the potential to rectify social dilemmas caused by top-down environmental governance, thereby guiding the public to acknowledge their identity as stakeholders in societal affairs, and cultivating both a sense of social responsibility and public awareness.

As a comprehensive and systematic social project, sustainable APWM necessitates collaboration amongst the government, enterprises, social organizations, and the public (Fig. 5). The government should reassess its position to facilitate a multi-entity cooperation governance pattern. Acting as the leading authority in environmental governance, the government should precisely diagnose each entity's realistic challenges regarding participating in APWM and accordingly, cultivate favorable external circumstances via guidance, incentives, and constraints. Enterprises should leverage their superiority in capital, technology, and management competence to boost profitability through technological research and development, process optimization, and industrial chain expansion, so as to promote advancement in market-oriented APW recycling and reduce the over-reliance on governmental subsidies. Furthermore, enterprises can proactively seek advanced partnerships with the government through service outsourcing and franchising to fully engage in the entire chain of APWM. Social organizations should leverage their role as a bridge and bond to convey public opinion upwards, advocate for environmentalist groups, and mobilize more social resources to enhance APWM. Downwards, they should serve as effective disseminators and educators by extending their reach into communities in a point-to-surface manner, communicating APWM-related policies, concepts, and knowledge to residents. Concurrently, social organizations should fully exercise their supervisory role, urging enterprises to better conduct APWM cause.

## 6. Conclusion and limitation

While there is a generally positive payment intention for APWM among the public, it is challenging to guarantee a desirable transition of intention into tangible payment actions. The study conducted an RCT to unearth the motivated mechanism that promotes the public to pay for APWM by information that notably boosts the public's WTP. Results evinced a general while varied increase in respondents' WTP for APWM by providing information targeted different TPB beliefs. Concretely, information targeting normative beliefs and control beliefs significantly elevated respondents' WTP by CNY 307.2 and CNY 400.5, respectively, revealing the public payment scheme is characterized by high perception, weak norm and lacking mechanism. Further analysis suggests that weak social norm and lacking of payment mechanism are the crux for the public payment scheme. Consequently, the scheme should center efforts on norm strengthening and mechanism establishing, adopting a multi-pronged approach to bridge the deficiencies to public payment for APWM. The findings of the study bring insights into the promotion of social utilities represented by sustainable APWM and provide theoretical reference for developing customized policies and social supports to guide the multi-entity cooperation landscape.

Although the study provides some interesting observations, there are still some limitations. While the experimental approach was effectively employed to validate the effectiveness of information intervention (Falk and Heckman, 2009), the study acknowledges the challenge of universality or external validity of the findings, which is a topic that experimental economics has been grappling with for decades (Falk and Heckman, 2009). Also, the different constructs of TPB before and after the intervention can be further quantified to further validate the effectiveness of the information content in influencing the corresponding intervention targets. Besides, respondents' self-reported WTP may overestimate their actual payment level, representing the inherent limitation when using WTP to assess individual preferences for non-market-value items (Knetsch and Sinden, 1984). Additionally, the study only established short term effectiveness of the information intervention, leaving the long term impact yet to be confirmed. In the upcoming research, with follow up field surveys and advancements in the WTP estimation methodology, the impact of information intervention on the APWM public payment scheme will be further revealed.

## CRediT authorship contribution statement

**Aibo Hao:** Writing – review & editing, Writing – original draft, Visualization, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Changbin Yin:** Writing – review & editing, Validation, Supervision, Resources, Project administration, Funding acquisition. **Thomas Dogot:** Writing – review & editing, Validation, Supervision.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jenvman.2024.123302.

## Data availability

Data will be made available on request.

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