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**TAPPING INTO THE SENSE OF ENTITLEMENT AND VISIBILITY
OF BEHAVIOURS TO PROMOTE HYDROCHAR RECYCLES IN
INDIA**

Vinayak GUPTA

Under the supervision of
Professor Fumitake TAKAHASHI



Doctoral Thesis

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In Partial Fulfilment of the Requirements

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August 2024

Declaration

I, Vinayak Gupta, a doctoral student at the Tokyo Institute of Technology, Japan, confirm that:

a. The work contained in the thesis is original and has been done by myself under the supervision of my supervisor.

b. I have conformed to the norms and guidelines given in the Ethical Code of Conduct of the Institute.

c. Whenever I have used materials (data, theoretical analysis, and text) from other sources, I have given due credit to them by citing them in the text of the thesis and giving their details in the references.

d. Whenever I have quoted written materials from other sources credit is given to the sources by citing them.

The contents embodied in the thesis have not been submitted for the award of any other degree or diploma in this or any other university.

Date: August 15, 2024

Place: Yokohama, Japan

Name of the Student: Vinayak Gupta

Name of the supervisor: Fumitake Takahashi

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This thesis stands as a testament to the collective effort and support of all these individuals. Any errors or oversights in this work are entirely my own.

Vinayak Gupta

August 15, 2024

Abstract of the thesis

Safe sanitation, recognized as a fundamental human right, remains a critical global challenge despite advancements in infrastructure and awareness campaigns since the 1800s. The interconnected issues of recycling, waste management, and sanitation have far-reaching consequences, particularly in urban and peri-urban areas where over 50% of the world's population resides. Recent data from the Joint Monitoring Programme indicates that over a third of the global population lacks improved sanitation facilities. Comprehensive strategies are urgently needed to address these challenges, integrating safe sanitation provision, recycling practices, and efficient waste management systems. Understanding public attitudes and behaviours towards these issues is crucial for formulating effective policies and interventions. This comprehensive study, hence, examines the critical intersections of community sanitation, waste management, and sustainable development. It initially emphasizes the importance of sanitation infrastructure for public health, highlighting persistent challenges despite initiatives like India's Swachh Bharat Abhiyan. The research identifies a high sense of entitlement as a key factor inhibiting toilet and public welfare scheme usage, proposing hydrochar-producing toilets as an innovative solution. The study employs the Theory of Planned Behaviour (TPB) to analyse citizens' intentions regarding hydrochar sanitation systems and utilizes cross-table analysis (CTA) to elucidate complex relationships among environmental variables, human behaviour, and sewage management. Visibility of behaviours emerges as a prominent factor influencing community actions through peer influence. In contrast, as per the existing literature, recycling intention is still low. The research, hence, extends its analysis to municipal solid waste, applying TPB and CTA to examine hydrochar acceptance from this source. This holistic approach offers valuable insights for policymakers to refine regulations and foster sustainable practices, ultimately exploring innovative solutions for a healthier, more sustainable future.

Keywords: Swachh Bharat Abhiyan, Qualitative and Quantitative survey, Data Analysis, Theory of Planned Behaviour, Structural Equation Modelling, Chi-square test, Cross table analysis, Sense of Entitlement, Visibility of Behaviour, Safe sanitation services, Hydrochar acceptance.

List of Abbreviations

AT	Attitude in the theory of planned behaviour
CEA	Carbon Emission Abatement
CTA	Cross Table Analysis
IN	Intention in the theory of planned behaviour
PBC	Perceived behavioural control in the theory of planned behaviour
PWS	Public welfare schemes
SBA	Swachh Bharat Abhiyan
SDG	Sustainable Development Goals
SEM	Structural Equation Modelling
SN	Social norms in the theory of planned behaviour
TPB	Theory of planned behaviour
WASH	Water, sanitation, and hygiene

Table of Contents

Title page	I
Declaration.....	II
Acknowledgment	III
Abstract of the thesis.....	V
List of Abbreviations	VII
Table of Contents	VIII
List of Tables	XII
List of Figures	XIII
Chapter 1	1
Urgency of Comprehensive Strategies in Recycling, Waste Management, and Safe Sanitation in developing and underdeveloped countries	1
1. Introduction	1
2. Research objectives	3
3. The flow of the thesis	4
4. Significance of the study	7
4.1. Academic perspective	7
4.2. Practical perspective	8
Ethical Considerations and due permissions.....	9
References	10
Chapter 2	13
Understanding the knowledge gap for the acceptance of community sanitation welfare schemes	13
1. Introduction	13
2. Materials and methods	17
2.1. Study area	17
2.2. Methodology.....	19
3. Results and discussion	23
3.1. Demographic distribution.....	23
3.2. Existing attitude towards defaecation and issues faced.....	24

3.3. Public trust in the wastewater management company and institutions' efforts in wastewater reuse	25
3.4. Respondents' choices and opinions on treated wastewater reuse	27
3.5. Awareness versus enthusiasm in the toilet construction process	30
3.6. Attitude of the respondents towards investment in the toilet building process versus using the toilet in its full capacity	30
3.7. Consumer behaviour towards paying for the toilet building service	31
3.8. Efficacy of the advertisements.....	32
4. Conclusion	33
4.1. Making urban sanitation more accessible	34
4.2. Informing policy formulation and implementation	35
References	35
Chapter 3	44
Navigating through the sense of entitlement to promote in-situ hydrochar acceptance	44
1. Introduction	44
1.1. Hydrothermal Carbonisation.....	44
1.2. Adoption of hydrochar_ a way forward	45
1.3. Toilets producing hydrochar	46
1.4. Theory of Planned behaviour, <i>Introduction of</i>	48
1.5. Cross table analysis, <i>Introduction of</i>	49
2. Research flow	50
3. Research methodology and data collection	52
3.1. Sampling and data collection	52
3.2. Demographic characteristics of the sample	53
3.3. Consistency and the validity of the dataset.....	53
3.4. Theory of planned behaviour (TPB)	54
3.5. Structural Equation Modelling (SEM).....	56
3.6. Chi-square test (χ^2 test, <i>Theory of</i>)	58
3.7. Cross-table analysis (CTA, <i>Theory of</i>).....	59
4. Results	61
4.1. Item measurements	61
4.2. Consistency and Validity test	63

4.3. Structural Equation Modelling	64
4.4. Chi-square testing and Cross-table analysis	68
5. Discussion	70
5.1. The usefulness of TPB in forecasting Indian individuals' intentions to utilize HSS and visibility of behaviour among the individuals.....	70
5.2. Discussion on the community reach and getting support for HSS technology .	72
6. Conclusion	72
References	73
Chapter 4.....	83
Expanding the theory of planned behaviour for municipal solid waste recycling.....	83
1. Introduction	83
2. Research flow	85
3. Research methodology and data collection	87
3.1. Sampling and data collection	87
3.2. Demographic characteristics of the sample	87
3.3. Consistency and the validity of the dataset.....	88
3.4. Theory of Planned behaviour.....	88
3.5. Chi-square test and Cross-table analysis, <i>Introduction of</i>	88
4. Results	88
4.1. Item measurements	89
4.2. Consistency and Validity test	90
4.3. Structural Equation Modelling	91
4.4. Chi-square test for independence and Cross-table analysis.....	94
4.5. Comparison of measured items' assertions and descriptive statistics of HSS and HMSW.....	98
5. Discussion	99
5.1. Applicability of TPB in predicting the intentions of Indian individuals to use HMSW.....	100
5.2. Influence of peer group, influential leaders, and neighbours on increasing awareness towards HMSW and getting governmental support	100
5.3. Relationship between getting support from the governmental schemes and increasing awareness of HMSW	102

5.4. Relationship between willingness to use HMSW and getting support from the government	103
5.5. Ease of putting money into HSS technologies	104
5.6. Discussion on the difference of SEM results on the acceptance of HSS and HMSW	105
6. Conclusion	106
References	107
Chapter 5	117
Conclusions	117
1. Findings at a glance	118
2. Recommendations	122
3. Limitations of this study and further expansions	122
4. Epilogue	124
References	125
Appendix	127
Appendix A	127
Appendix B	132
Appendix D.1	144
Appendix D.2	148
Appendix E	153
Appendix F	160
Appendix G.1	161
Appendix G.2	165
Appendix H	170
Appendix I	175
Appendix J.1	178
Appendix J.2	182

List of Tables

Chapter 2

Table 2.1: Questionnaire in this study.....20

Table 2. 2: Demographic summary of the respondents.....23

Chapter 3

Table 3.1: General format for the Chi-square test and CTA (unit: number of respondents)....58

Table 3.2: Measured items' assertions and descriptive statistics, representing attitude, subjective norm, perceived behavioural control, and intention.61

Table 3.3: Shapiro-Francia W-value of each item set (α kept as 0.05)63

Table 3.4: Model-implied covariances for latent variables.....68

Table 3.5: Heat mapping of the CTA results (refer to Appendix F for the numerical values) .69

Chapter 4

Table 4.1: Measured items' assertions and descriptive statistics, representing attitude, subjective norm, perceived behavioural control, and intention.89

Table 4.2: Shapiro-Wilk W-value of each item set (α kept as 0.05)91

Table 4.3: Model-implied covariances for latent variables.....94

Table 4.4: Heat mapping of the CTA results (refer to Appendix I for the numerical values) ..95

Table 4.5: Comparison of mean of the survey data of each item for HSS and HSMW98

List of Figures

Figure 1: Proposed flow of the thesis	5
Figure 2: Satellite imagery of Jaipur City (Rajasthan, India) marked under red-coloured boundary (procured from Google Maps on 13 January 2022).....	18
Figure 3: Satellite imagery of Kho Nagorian in Jaipur City marked as a red-coloured indicator (procured from Google Maps on 13 January 2022).....	19
Figure 4: Schematic representation of the Blue Diversion Autarky Toilet (BDAT), with the front-end (toilet superstructure including a urine-diverting flush toilet with solids separator, waterless urinal, handwash water tank with tap and handwash basin) and backend technologies (water and urine treatment) (Sutherland, Reynaert, Dhlamini, et al., 2021).....	47
Figure 5: Flowchart depicting research flow. Abbreviations used in this flowchart are as follows: TPB for the theory of planned behaviour, CTA for cross-table analysis and SEM for structural equation modelling.	51
Figure 6: Standardized factor loadings and path coefficients of the final structural model based on the TPB, redrawn for better clarity (the actual figure generated by the Jamovi software can be accessed in Appendix E). Triangles represent error terms, squares represent measured items, circles represent latent constructs, straight arrows represent dependence relations and curved arrows represent correlational relations. Dotted arrows indicate insignificant effects, or the default values of latent variables (unit value). Abbreviations used are as follows: IN for intention, AT for attitude, SN for social norms, and PBC for perceived behavioural controls.	66
Figure 7: Flowchart depicting research flow. Abbreviations used in this flowchart are as follows: TPB for the theory of planned behaviour, CTA for cross-table analysis and SEM for structural equation modelling.	86

Figure 8: Standardized factor loadings and path coefficients of the final structural model based on the TPB, redrawn for better clarity (the actual figure generated by the Jamovi software can be accessed in Appendix G). Triangles represent error terms, squares represent measured items, circles represent latent constructs, straight arrows represent dependence relations and curved arrows represent correlational relations. Dotted arrows indicate insignificant effects, or the default values of latent variables (unit value). Abbreviations used are as follows: IN for intention, AT for attitude, SN for social norms, and PBC for perceived behavioural controls.

.....93

Urgency of Comprehensive Strategies in Recycling, Waste Management, and Safe Sanitation in developing and underdeveloped countries

1. Introduction

Safe sanitation is a fundamental human right. There have been advancements in sanitation infrastructure and awareness campaigns since the 1800s, yet open defecation remains a pressing issue in many parts of the world (McMichael, 2018; Zuin et al., 2019). This, including the issues of recycling, waste management, and safe sanitation have emerged as critical global challenges with far-reaching consequences (Abanyie et al., 2022a). Acknowledging the fact that more than 50% of the world's population is located in urban and peri-urban areas (Simon, 2008), many of these areas lack access to clean water and sanitation needed to ensure proper health and well-being (Moe and Rheingans, 2006). A report by the Joint Monitoring Programme (JMP) indicates that more than 10% and over a third of the world's population lack access to potable drinking water and improved and adequate sanitation facilities respectively (UNICEF, 2024). As populations have grown rapidly and urbanization has accelerated, the strain on existing waste disposal systems has been intensified, demanding innovative and sustainable solutions. Despite efforts on promoting toilet usage, and existing studies on recycling, waste management, and sanitation, there is a need to explore the interconnected facets of recycling, waste management, and safe sanitation as a collective global predicament, emphasizing the need for comprehensive strategies to address these challenges.

Recycling, waste management, and safe sanitation are interwoven elements crucial for maintaining public health, environmental sustainability, and social well-being. According

to UNICEF (2017), globally, about 2 billion people lack basic sanitation facilities (UNICEF, 2017). WHO (2021) revealed that in developing countries, the proportion of people lacking access to improved sanitation and drinking water is substantially higher (UNICEF and WHO, 2021). For instance, in sub-Saharan Africa, 70% of people respectively lacked access to sanitation facilities. In Ghana, for instance, only 18% of the country's population has access to sanitation (Abanyie et al., 2022b). These deficiencies in the water, sanitation, and hygiene (WASH) sector impose tremendous financial, health, and environmental costs on developing countries and their inhabitants (UNICEF, 2017).

The improper disposal of human waste not only pollutes the environment but also poses severe health risks, particularly in areas lacking proper sanitation infrastructure. A study by Prüss-Ustün et al., (2014), reported that out of the 842,000 global deaths due to diarrheal disease, 280,000 were due to inadequate sanitation. Improved water supply and sanitation provide individuals with increased comfort, safety, dignity, status, and convenience, and also have broader effects on the living environment (Hutton and Chase, 2017). Consequently, addressing these issues requires a holistic approach integrating the provision of safe sanitation facilities, recycling practices, and efficient waste management systems. In addition, understanding public attitudes and behaviours toward recycling, waste management, and sanitation is integral to formulating effective policies and interventions (Babaei et al., 2015). Public opinion research, as highlighted by Glynn and Hüge (2008), is a valuable tool in this endeavour (Glynn and Hüge, 2008). By engaging with direct beneficiaries and local communities, such research provides insights into the perspectives that shape waste disposal habits and sanitation practices.

Moreover, cross-table analysis (CTA), a statistical technique discussed by Agresti (2018), becomes instrumental in unravelling the complex relationships among variables such as demographics, behaviour towards public welfare schemes (PWS), financial willingness for toilet construction, and product preferences (Agresti, 2018). This study, hence, delves into two

critical aspects that intersect in the pursuit of healthier and more sustainable communities. The first part explores the ongoing challenges in community sanitation, specifically in the slum areas of Jaipur, India, while the second part addresses a solution by tapping into the sense of entitlement prevalent in the community. This is done by introducing hydrochar, a bio-based product used as a fuel or soil additive, which caters to the mounting issue of sewage treatment and municipal solid waste (MSW) and the potential solution through hydrothermal carbonisation (HTC) in the same region.

2. Research objectives

Sanitation and recycling are interwoven and to address the issues, a multidisciplinary approach is required. This study, hence, aims to cater to the following three major research objectives, and four additional minor objectives:

- 1. To understand public perception and attitudes towards sanitation practices, particularly in slum areas of Jaipur, India.**
- 2. To explore the possibilities of adaptation of hydrochar derived from in-situ sewage sludge (SS) as a sustainable energy source to tap the sense of entitlement.**
- 3. To explore the possibilities of adaptation of hydrochar derived from municipal solid waste (MSW).**

Additionally, this thesis also answers the following minor objectives, results that were found while finding answers to the above questions.

4. To assess the impact of Swachh Bharat Abhiyan (SBA) on community sanitation, and to explore the persistence of open defecation in slum areas despite the successful implementation of SBA through an on-site qualitative survey.

5. To contribute to the understanding of factors influencing public perception and behaviour related to sanitation, aligning with the United Nations' SDG 6.2.
6. To evaluate the level of citizen engagement in recycling initiatives, with a focus on the low adoption of recycling practices and the potential of SS and MSW-derived hydrochar (HSS and HMSW, respectively);
7. To provide insights to aid policymakers in developing policies and carbon emission abatement (CEA) programs to improve sustainability, considering citizen motivations for recycling MSW.

3. The flow of the thesis

This comprehensive study delves into the critical intersections of community sanitation, waste management, and sustainable development. This study initially focuses on the importance of sanitation infrastructure for public health, it highlights the challenges persisting in certain areas despite initiatives like the SBA in India. Transitioning to a broader environmental perspective, this study finds that one of the main reasons for the communities not using the toilets or the PWS is the high sense of entitlement, and hence proposes toilets that produce hydrochar as a transformative solution. The connection between sanitation and waste management is crucial. This highlights how these issues are linked together, and so the discussion extends to the adoption of hydrochar from SS. The final segment introduces the TPB to analyse citizens' intentions in using HSS. The study then employs CTA additionally to unravel the complex relationship between environmental variables, human behaviour, and sewage management, offering insights for policymakers to refine regulations and foster sustainable practices. After studying TPB and CTA on SS, the study finds the visibility of behaviours as one of the prominent reasons for the community getting influenced by their peers. Tapping onto this

visibility of behaviour, this study extends to MSW and performs TPB and CTA on hydrochar made from MSW and its acceptance. Overall, the research provides a holistic understanding of the challenges faced by communities and explores innovative solutions for a healthier, more sustainable future. Below is the flow chart of the proposed study (Figure 1), followed by the distribution of this study chapter-wise.

The flow of the thesis:

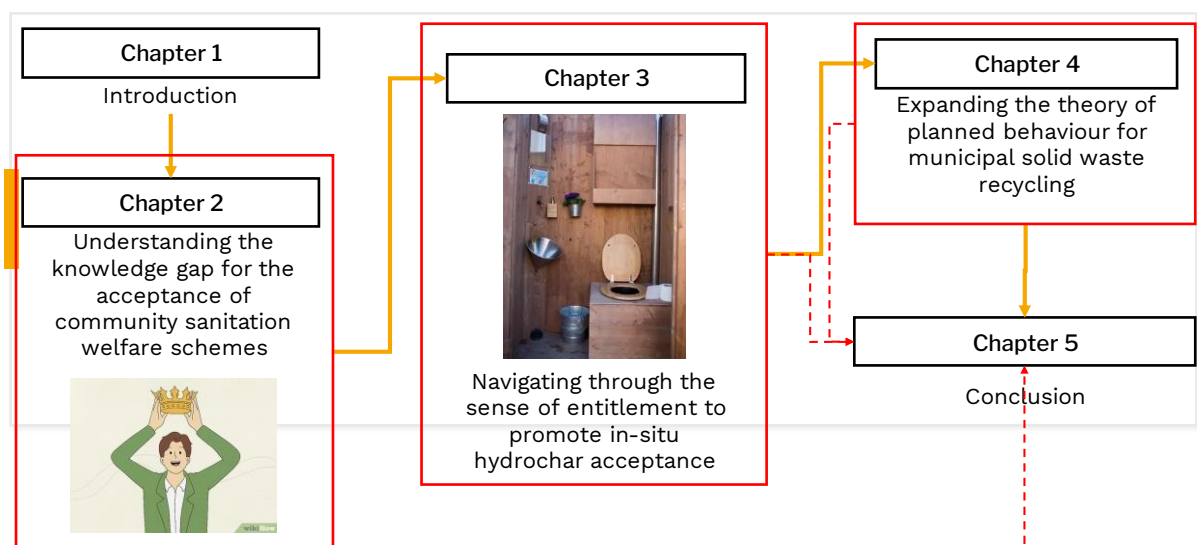


Figure 1: Proposed flow of the thesis

Chapter 1, the current chapter, emphasizes the need to conduct this study. It also discusses the significance of this study and provides insights on the further distribution of chapters.

Chapter 2, titled “Understanding the knowledge gap for the acceptance of community sanitation welfare schemes”, discusses a sociological survey to gather the thoughts and perceptions of residents in the slum areas of Jaipur to understand factors that influence public and consumer perceptions of toilets. Through improved communication and involvement, addressing public issues has encouraged more productive public dialogue and helped to

strengthen public confidence and trust. The data acquired is further investigated to study the relationships between variables such as demographics, behaviour towards public welfare schemes, enthusiasm to pay money for toilet building, and product preferences. This chapter, interestingly, points out that the community has a high sense of entitlement, often defined as a sense of deservingness or being owed a favour when little or nothing has been done to deserve special treatment, and this is one of the many unreported reasons which is making a community does not avail of the benefits of a PWS.

Chapter 3, titled “Navigating through the sense of entitlement to promote in-situ hydrochar acceptance” transitions from the result of Chapter 2, i.e., identification of the high sense of entitlement and how to tap into the sense of entitlement. It is proposed that to tap into this virtue, something should be introduced to lure people to keep using the product. Hence, the concept of toilets producing in-house hydrochar, a fairly new technology, is introduced. This chapter then discusses how hydrochar, an energy product, made from sewage can be accepted by the local people as a solution to cater to the overburdened sewage treatment plants and improper sanitation. An extensive literature review on the process of making hydrochar from sewage and the technology used by those hydrochar-producing toilets is followed by the study of TPB to pinpoint the psychological variables affecting people’s intentions and behaviours on the same. As the TPB illuminated the psychological determinants influencing human behaviour, laying the foundation for an in-depth discourse on the motivations driving recycling efforts, this chapter additionally incorporates CTA to unravel the intricate relationships among various variables, providing valuable insights into the multifaceted factors influencing human behaviour within the sewage management paradigm. It was noted that social norms (SN) have the highest influence on people’s intention (IN) to use hydrochar made from SS. This gives rise to another question, if SN has the highest influence on the intention to use hydrochar, a

form of recycling, why is the adaptation of recycling still low worldwide, leading to the need for further exploration in Chapter 4.

Chapter 4, titled “Expanding the Theory of planned behaviour for municipal solid waste recycling”, delves further into overall waste management, and is not just confined to sewage management. Similar to Chapter 3, it incorporates TPB to gauge the acceptance of hydrochar, specifically from MSW, and conducts CTA additionally on the prominent issues and items for the hydrochar made from MSW. Significantly, it discusses the reasons why SN is greater than SS recycling than MSW recycling.

Chapter 5, the last chapter, discusses the limitations of this study, further possible expansion of this study, and applications of this work done during the doctorate study.

4. Significance of the study

The significance of the study highlights the benefits that are expected to accrue after the study is completed. The significance can be looked at from two perspectives, academic perspective and practical perspective.

4.1. Academic perspective

The academic significance entails how the study would contribute to the existing body of knowledge on the said topic, as mentioned below.

4.1.1. Methodological Contribution

Several studies have introduced innovative methodologies and refined existing ones in the study of recycling, waste management, and sanitation. This study would involve novel approaches to data collection as per both qualitative and quantitative surveys, statistical analysis, and survey designs, enhancing the toolkit available to researchers in the field.

4.1.2. Generation of New Data

This research provides new and updated data, filling gaps in the existing knowledge. This includes insights into current global trends, regional disparities, or specific challenges faced by communities, in particular low-income groups and middle-class groups in developing countries like India. New data is crucial for policy-making and future research endeavours.

4.1.3. Validation or Refutation of Previous Findings

Studies may validate or refute previous findings, contributing to the ongoing dialogue within the academic community. This iterative process is vital for refining understanding and ensuring the reliability of research outcomes.

4.1.4. Policy Implications

Academic significance has direct implications for policymaking. Research findings are expected to inform the development of effective policies and interventions that contribute to the practical application of academic knowledge in real-world scenarios.

4.2. Practical perspective

The practical significance of the study would be the impact and benefits that different stakeholders would derive from the findings of the study, as discussed below.

4.2.1. Global Implications and Challenges

The magnitude of the recycling, waste management, and sanitation challenge extends beyond national borders, making it a global concern. Developing and underdeveloped countries grapple with inadequate infrastructure, limited resources, and a lack of awareness, exacerbating the problem. Conversely, even in developed nations, issues like electronic waste and single-use plastics contribute to the global crisis (Nandy et al., 2022; Ortiz et al., 2020). Bridging the gap between nations and fostering international collaboration is essential to implement effective solutions.

4.2.2. Policy Interventions and Government Schemes

Government initiatives are vital to address the global problem of recycling, waste management, and safe sanitation. Implementing and enforcing robust waste management policies, investing in infrastructure, and promoting sustainable practices are necessary steps. The findings from public opinion research and the CTA will inform the design and implementation of government schemes, ensuring that they align with the actual needs and perceptions of the communities they aim to serve.

4.2.3. Educational Initiatives and Community Engagement

An informed and engaged community is essential for the success of any recycling, waste management, and sanitation initiative. Educational programs that raise awareness about the environmental impact of improper waste disposal, the benefits of recycling, and the importance of safe sanitation practices can foster a culture of responsibility. Community engagement ensures that the public becomes an active participant in sustainable waste management efforts, promoting a sense of ownership and accountability. Recycling, waste management, and safe sanitation represent a global challenge that demands urgent and concerted efforts. Public opinion research, CTA, technological innovations, and government policies are crucial components of a comprehensive strategy to tackle these issues. As the complexities of waste management and sanitation are navigated on a global scale, it is imperative to prioritize inclusivity, considerate policy design, and the empowerment of communities to create a sustainable and healthier future for all.

Ethical Considerations and due permissions

The survey data utilized in this research paper is of a confidential nature and cannot be shared with external parties due to privacy and ethical considerations. The survey and the data

collection were approved by the Human Subject Ethics Review Committee of the Tokyo Institute of Technology through permit number 2023118 on August 7, 2023.

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Understanding the knowledge gap for the acceptance of community sanitation welfare schemes

1. Introduction

Community sanitation is a prerequisite for healthy societies. It relates to public health issues such as safe drinking water, as well as the treatment and disposal of excreta. Sanitation systems are designed to preserve human health by creating a clean environment that prevents disease transmission, mainly via the faecal–oral pathway. This has evolved into a way of life, despite its origins as a means of achieving preventive health-related problems. The principle of sanitation is to transfer all decomposable matter, solid waste, liquid, and gaseous waste from dwellings immediately after production to a designated waste treatment facility. In this sense, a country's sanitary infrastructure development potentially serves as a sensitive indicator of economic growth. While potable drinking water is essential in providing environmental engineering services, the importance of an up-to-date sewerage system cannot be overlooked. It cannot be allowed to fall behind, as all of the water used by the community must flow back as excreta loaded with the waste of community living unless adequately collected, treated, and disposed of; this would create serious water pollution problems (Herbig, 2019; Jin et al., 2014).

Poor sanitation can cause water pollution problems, and it is an important issue in developing countries (Montgomery & Elimelech, 2007; Tilley et al., 2013). Though around \$114 billion per year is spent on sanitation services (The World bank, 2015), still, worldwide, an estimated 2.6 billion people live without satisfactory sanitation services (Lee & Bellamy, 2004). In India, during the 1980s, the rural sanitation coverage was estimated to be 1% (UNICEF, 2018, p. 6).

Since 1980, various government programs at the central government, state government, and local municipality levels have resulted in rapid improvements in sanitation and drinking water delivery (UNICEF, 2018, p. 6). Swachh Bharat Abhiyan (SBA), also known as the Swachh Bharat Mission or Clean India Initiative is one such attempt to address the sanitation problems faced by communities in India (National Informatics Centre Government of India, 2022). It is a country-wide campaign initiated by the government of India in 2014 to eliminate open defaecation and improve solid waste management. The campaign aims to achieve an "open-defaecation-free" country by constructing community toilets. This campaign was divided into several phases, wherein the first phase was completed in October 2019.

Under the SBA, the first phase included eradication of manual scavenging, generating awareness, and bringing about behavioural change regarding sanitation practices, and augmentation of capacity at the local level. Though this campaign has achieved its target to a greater extent (Aggarwal, 2021; Curtis, 2019; Geruso & Spears, 2018; Hutton et al., 2018), open defaecation in slum areas remains prominent (Aggarwal, 2021). In the country, about 67% of rural and 12% of urban households still practice open defaecation (Chaudhuri & Roy, 2017). Despite the successful implementation of SBA, local populations still use manual scavenging and open defaecation. In the 1800s, manual scavenging and open defaecation were mainly due to the caste system (Singh, 2016). The caste system was banned in 1950, but open defaecation is still prevalent. In addition, recent studies have shown that the rural sanitation sector in India is marked by intense spatial inequality and heterogeneity (Chaudhuri et al., 2018; Chaudhuri & Roy, 2017). There have been studies and opinions in academia on what it will take for people to actually use government-subsidized toilets (Diane Coffey et al., 2024; Sriroop Chaudhuri & Mimi Roy, 2018). The reasons for this can be understood through public opinion research, which includes target interviews with the direct beneficiaries and the local communities, and by understanding their perspectives. Public opinion research, including highly structured

laboratory exercises and observation of people's behaviour, aids in identifying the information needed to address organisational and service issues. It helps in weighing public perception on a specific issue, such as when government contractors call to inquire about access to healthcare or social services, or when there is a need to understand why a community is not using toilets. A survey study also helps in understanding prevalent societal issues, such as problems incurred during the construction of a toilet and the implementation of a government scheme.

In the past, similar contingent valuation surveys have been used to investigate the main variables of excreta reuse, such as water conservation, health and environmental benefits, hesitancy to use wastewater, treatment costs, religious restriction, education, and awareness level (Guo et al., 2012; Kantanoleon et al., 2007; Marks, 2006; Nassar et al., 2009). These conclusive elements determine whether a wastewater-reuse project will succeed or fail. For example, a study found that the water, sanitation, and hygiene (WASH) practices among the tribal population of Tamil Nadu, India are not acceptable (Saha et al., 2020). Similarly, on a global scale, in a study by Kantanoleon et al. (2007), a questionnaire was sent to the parents of high school students in Chalkida City, to gauge public opinion on wastewater reuse. The results indicated that the public was optimistic about the industrial application of wastewater reuse (76%) (Kantanoleon et al., 2007). In a similar study by Marks (2006) food-related uses, such as animal crops and vegetable cultivations, were discussed. In the survey conducted in the United States (47–74% public acceptability) and Australia (> 95% public acceptability), the public expressed strong support for wastewater reuse in industrial sectors, public parks, school grounds, and golf course irrigation (Marks, 2006). However, the public's main concern was potential health problems associated with recycled water (Kantanoleon et al., 2007; Marks, 2006). The findings revealed that environmental and socio-economic factors play a significant role in excreta reuse applications (Jasim et al., 2016; Kumar et al., 2017). Sharing relevant information, on the other hand, can improve public support for the reuse ideas (Al-Khatib et

al., 2015; Hartley, 2006). Therefore, efforts should be made to encourage broader thinking among the public for the reuse of excreta (Smith et al., 2018).

Through improved communication and involvement, addressing public issues can encourage more productive public dialogue and help to strengthen public confidence and trust. For this reason, the public's perspective was studied to determine people's willingness to reuse treated excreta, and their attitude towards basic hygiene. Consequently, this research adds to recent data on public attitude towards an ongoing public welfare scheme (PWS). In this light, this study conducted a sociological survey to gather the thoughts and perceptions of residents in the slum areas of Jaipur to better understand factors that influence public and consumer perception. To further investigate the relationships between variables such as demographics, behaviour towards the PWS, enthusiasm to pay money for toilet building and product preferences, cross-table analysis has been conducted. A cross-table analysis (CTA) is a statistical technique used to examine the connection between two or more categorical variables (Agresti, 2018). The analysis comprises a table detailing the percentage or frequency of observations for each group of the variables under consideration. The final table is referred to as a cross-tabulation or a contingency table which enables spotting patterns and connections between the variables by demonstrating how the categories of one variable relate to the categories of another variable (Agresti, 2018). CTA is a commonly used method in public health and environmental research. In Ghana, a study applying the CTA to examine disease transmission and the separation between homes and final disposal sites revealed that people living closer to open dump sites were more likely to contract related illnesses like malaria and skin infections (Suleman et al., 2015). Similarly, the outcomes of this study can be applied to design public benefit schemes in many developing countries around the world. This survey, thus, aims to assist in decision-making regarding tax money allocation by reflecting public concerns, views, and values. In addition, this study also aims to contribute towards target 6.2 of the Sustainable Development

Goals Number 6 established by the United Nations in 2015 (Global Indicator Framework for the Sustainable Development Goals and Targets of the 2030 Agenda for Sustainable Development, 2017).

2. Materials and methods

The study has been narrowed down to the Kho Nagorian slum area in the city of Jaipur. Home to around four million residents (World Population Review, 2023), Jaipur is widely celebrated as a famous tourist spot and is a UNESCO World Heritage City. This section discusses the sanitation issues in Jaipur and the approach and methodology of the citizen survey used in this study.

2.1. Study area

Jaipur is the capital and largest city of the Indian state of Rajasthan. The city is 268 kilometres (167 miles) from New Delhi, the national capital of the country. Jaipur is situated at a latitude of 26° 55' N and a longitude of 75° 49' E, whereas its municipal limit stretches from 26° 46' N latitude to 27° 01' N latitude, and from 75° 37' E longitude to 76° 57' E longitude (Figure 2). The area of study is a “*kasba*” or locality known as Kho Nagorian which is located at about 13 km SE of the walled city of Jaipur (Figure 3). This area is dominated by an uneducated class, mostly unskilled labour.

The daily solid waste generation in Jaipur is almost 1100 MT (metric tonnes)/day (Olivier et al., 2011). In Jaipur, around 200-250 MT is left on the streets and highways, implying an overall lifting efficiency of around 80%. The per capita solid waste creation per day is roughly 350 grams, equating to 1.75 kg per day for a family of almost five (Olivier et al., 2011). The lack of a community garbage collection facility in slums is a common sight wherein slum residents dump their rubbish near their residential areas (Kumar et al., 2018; Nandwana & Chhipa,

2014). Due to the onset of SBA, these sites have drastically improved, though there is a long way to complete transformation (Mathur et al., 2019). Despite efforts, some areas in old Jaipur face overflowing garbage cans and indiscriminate dumping (Times News Network, 2021). Burning of waste leads to thick smoke on roads. Many drains and sewers near Mother Dairy, Bais Godam, Durgapura and Pratapnagar remain blocked due to improper waste disposal (Kumar et al., 2018; Nandwana & Chhipa, 2014). The lack of convenient excreta disposal facilities and their treatment in less developed areas, including the slum area of the Kho Nagorian, encourage people to use neighbourhood open lands for defaecation.

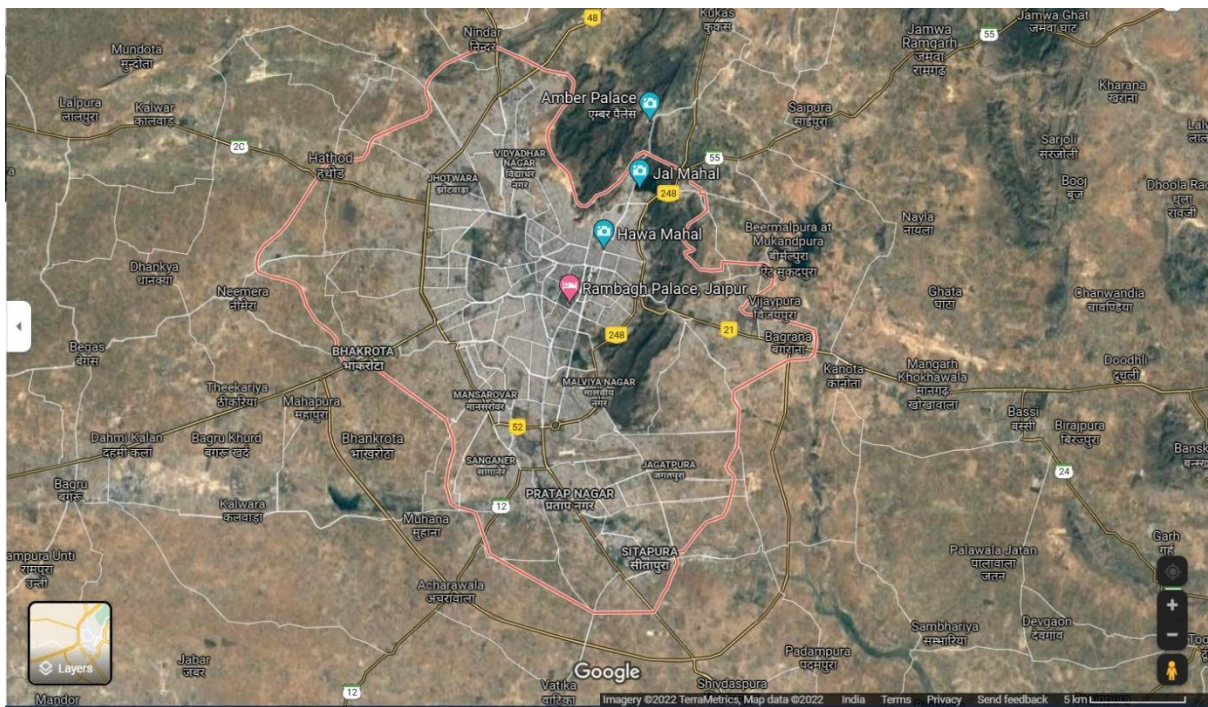


Figure 2: Satellite imagery of Jaipur City (Rajasthan, India) marked under red-coloured boundary (procured from Google Maps on 13 January 2022)

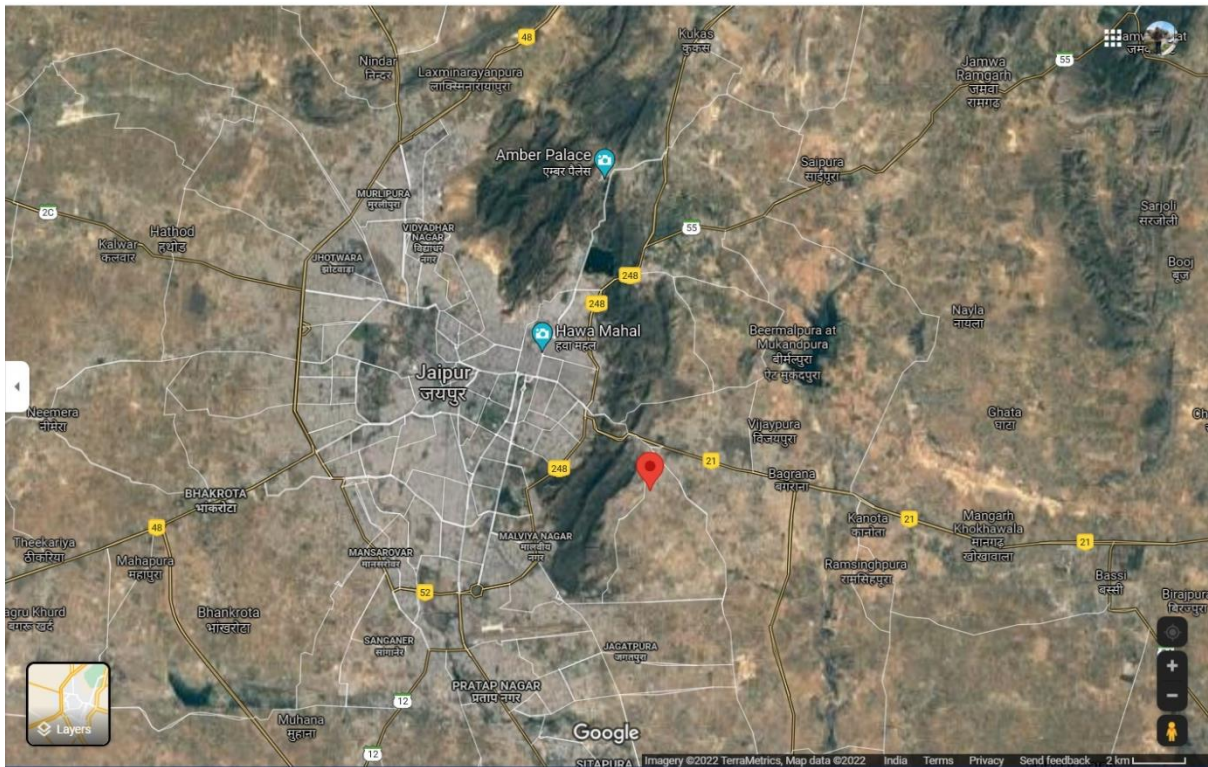


Figure 3: Satellite imagery of Kho Nagorian in Jaipur City marked as a red-coloured indicator (procured from Google Maps on 13 January 2022)

2.2. Methodology

A collection of preliminary data was acquired using a qualitative survey in a low-income community. After getting the public responses, trends in user behaviour were observed and further CTA has been performed to analyse further relationships between the variables.

2.2.1. Collection of preliminary data

Residents' concerns regarding the success of the SBA and their attitude toward the sanitation practices were collected through a qualitative survey and participatory appraisal. The qualitative survey was performed per the Declaration of Helsinki and was approved by the Human Subject Ethics Review Committee at the Tokyo Institute of Technology (permit number 2023118). Informed consent was obtained from all the participants and/or their legal guardian(s) (in cases where the participant was illiterate). The households were chosen

randomly from the Kho Nagorian village so most of them do not have a toilet in their residences as of November 2020. The responses were divided into two categories: households with and households without toilets. A face-to-face random sampling among sixty households from different parts of Kho Nagorian village was carried out, which included not only the men (considered to be the head of the household) but also women. Out of the sixty households, eight households were omitted due to verification problems.

Out of those remaining fifty-two households reported, fifteen households have toilets on their premises. The rest, thirty-seven households, do not have access to a basic sanitation facility. The questionnaire was designed in both English and Hindi, wherein Hindi is the language spoken by individuals. Table 2.1 is the display of questions asked in the survey.

Table 2.1: Questionnaire in this study

Question number	Question
1	Why is the individual not using a toilet?
2	Where do the male members go for defaecation?
3	Where do the female members of the household go for defaecation?
4	Where do the kids of the household go for defaecation?
5	Does the individual face any problems due to not having a toilet facility? What are they?
6	Does the individual think having a toilet can significantly improve above mentioned problems? If no, then how?
7	Does the individual intend to pay more expenditure of money than the government's aid for the construction of toilets if it exceeds the subsidy?
8	In case there is no money from the government would the individual still construct a toilet at his/ her own expense?
9	According to the individual, how much money does it cost to construct a toilet?

10	What problems does the individual incur with/while constructing a toilet?
11	How much money is the individual happily willing to pay for a good toilet facility in your house?
12	What does the individual think of toilets which are low in cost and fast to construct?
13	Would the individual be interested in constructing a fast (in some hours) and easy-to-install toilet for his/ her family?
14	What material does the individual think toilets should be made of?
15	Where does the individual see advertisements for toilets?
16	What are the individual's perceptions regarding using pit humus from the toilet?

The following subjects were considered (refer to Appendix A for the detailed questionnaire):

- Demographic information, including gender, age ranks, contact number and the number of family members
- Behavioural questions about the usage of toilets by family members
- Issues faced while opting for open defaecation
- The attitude of people towards the construction of a low-cost toilet
- Awareness of people towards the SBA scheme
- Willingness to use the pit humus obtained from treating the excreta from the toilet

Out of these fifty-two households, only two households practice the Hindu religion, while it was noticed that the rest of the fifty households were Muslims. Each household had a distinct contact number/ cellular phone number to maintain a unique identity. This did not allow the repetition of answers from the same household. The said on-site survey was conducted in November 2020, to determine public responses to the concept and application of the construction of toilets and the attitude towards safe defaecation. Collected questionnaire forms

were imported into Microsoft Excel for further analysis using statistical tools to develop descriptive statistics.

2.2.2. Further investigation through CTA

CTA has been performed on the following cases:

- To understand the trend between the awareness of how much the toilet building will cost to the respondents and the enthusiasm to construct a toilet, a CTA has been performed on Question 9 and Question 12. Question 9 tests the awareness of the respondents and tells if the people are aware of the toilet building cost. Question 12 gauges enthusiasm in the toilet construction process.
- Question 11 has been cross analysed with Question 16 to understand the trend between investing in a facility, here, a toilet, and using it.
- A CTA between Question 7 and Question 11 will help to understand the intricacies of human consumer behaviour. Question 7 takes note of the hypothetical willingness to pay for the toilets, and, on the other hand, Question 11 elucidate on the actual willingness to pay money for a toilet building. A comparison between them would help to understand if people would pay for the service in real, rather than hypothesizing it, or if they might not want to pay in actuality, but end up paying nevertheless.
- To deduce the efficacy of advertisements, Question 15 has been analysed across Question 11 and Question 12. Question 15 tells if the respondents have come across an advertisement related to sanitation and hygiene or not.

3. Results and discussion

This section comprises a discussion of the demographic distribution of the study area. The results of the survey are divided into three sections: (1) the existing attitude of the local community towards defaecation and associated issues, (2) public trust in wastewater management companies and government efforts in wastewater reuse, and (3) the opinions of the local community on treated wastewater reuse. The results of the CTA have been discussed afterward in four subsequent sections.

3.1. Demographic distribution

The demographic data of the respondents is presented in Table 2.2. Males made up 80.77% of the responders, while females made up 19.23%. The average number of family members is 7.19. Such demographic data aid in defining the population composition, which is vital in understanding acceptance and attitude towards the SBA and excreta reuse initiatives investigated in this survey.

Table 2. 2: Demographic summary of the respondents

Attributes	Distribution	Units
Total number of valid entries	52	Individuals
Number of male respondents	42	Individuals
Number of female respondents	10	Individuals
Age of oldest respondent	73	Years
Age of youngest respondent	30	Years
Average family size	7.19	family members
Lowest family size	3	family members
Highest family size	30	family members

Kho Nagorian is a Muslim-dominated area. All the respondents come from the below poverty line (BPL) families and are indulged in unclassified work, like being a porter on construction sites, being a fruit or vegetable vendor, etc. High average family size is a typical characteristic of low-income Muslim families, as mentioned by a study conducted by the Pew Research Centre (Washington, D.C) in 2017 (Lipka & Hackett, 2017).

3.2. Existing attitude towards defaecation and issues faced

Question 1 to Question 5 in Appendix A deal with the existing attitude towards defaecation and the issues associated with open defaecation. These questions were asked to thirty-seven families with no existing toilets in their households. These families opted for open defaecation.

Figure B.1 in Appendix B shows that about 89% of the responses declared financial constraints, and about two individuals opted for “other reason”. While one respondent could not argue the said “other reason”, the other mentioned that the landlord did not provide a toilet in the household. About 6% of the respondents, or two households preferred open defaecation due to fresh air and open fields.

As far as places for the open defaecation is concerned, Figure B.2 in Appendix B compares the preferred places for open defaecation. The respondents are categorized as males, females, and kids. It is observed that there is a similar pattern in all three categories. Most respondents preferred to defaecate in an open *nallah* (an open drain to allow rapid drainage of rainfall or industrial wastewater.) The next preferred option for open defaecation is a nearby hill. The other options are jungle, nearby agricultural lands, lush green lands, and open barren lands. Regarding “other” responses recorded in the survey, one of the household chiefs was too old to understand the questions posed to him, so his response was excluded. This is noted as “others”. A lady has put in her response as a *doongar*, put in as the “other category”. A *doongar* is a nearby hill in local language but has been put in the “others” category to maintain the

validity of the responses in the survey. Two families did not report any kid in their households, so their responses in question 4 have been marked under “others”. It is noted that though there were community toilets, families did not use them. This might be due to the prominent two reasons. One, the community toilet was not in their “*dhani*”, or neighbourhood, and two, community toilets were poorly maintained.

In addition, there have been issues faced by the inhabitants while opting for open defaecation which is shown in Figure B.3. Twenty-five households reported facing harassment from society because of open defaecation. In addition, accounts of illness related to unhygienic practices were reported. Additional responses included encounters with snakes and insects in the jungle and nearby hills. Time constraints and a desire for privacy during defecation were reported as well. The responses in the “others” category were that the children have pathogens in the stomach, there were inconveniences during the rainy season, and potable water was scarce onsite. A respondent said her impaired daughter defecates at home. Three households have reported that they have no issues with open defaecation.

3.3. Public trust in the wastewater management company and institutions' efforts in wastewater reuse

This argument is discussed in the context of Questions 10 and 15 to every household with or without a toilet in their houses. The number of responses, henceforth, is fifty-two. This section is further divided into two sections: understanding the problems incurred during toilet construction including the public trust in the wastewater management company and investigating the role of public institutions to influence the community's behaviour.

3.3.1. Understanding the problems incurred during toilet construction and public trust in the wastewater management company

Question 10 tries to understand the problems incurred during toilet construction, and the responses are shown in Figure B.4 (Appendix B). Thirty-seven respondents felt that there is a lack of funds and resources to construct a toilet. This is followed by a lack of conviction towards the government officials and contractors that the said contractor might do a substandard job while retaining a fraction of the money earmarked for purchasing materials for construction, as shown in Figure B.4. Two respondents had no idea what it takes to construct a toilet. Question 15 tests the awareness towards the SBA. About twenty-one individuals have seen an advertisement in the government dispensary and eleven households have been informed by their kids as the kids are being advised about toilets in their schools (Figure B.5). Ten respondents have seen and heard about the toilets on cellular phones and televisions, and six individuals have also seen advertisements on village walls. This number is higher than those who have not seen or heard an advertisement about the SBA or the usefulness of toilets which counts to twenty-four. This value does not indicate a complete absence of advertisements seen within the respondent's household. Rather, it illustrates that only the specific respondent has not been exposed to any advertisement of toilet-building schemes.

3.3.2. Investigating the role of public institutions in influencing the community's behaviour

Studies have shown that lower-income individuals hold stronger religious beliefs than their higher-income counterparts (*Role of Religiosity in the Lives of the Low-Income Population*, 2009). In addition, places of worship can be a suitable setting to encourage public engagement and spread ideas relating to health promotion (Ali, 2021). In developing countries, this trait of a community can be used to influence the community's behaviour. Here, it is proposed that the religious places of worship, mosques (as far as this study is concerned because 96% of

respondents practice Islam), can be used to encourage hygienic practices and inform people about government programmes in areas where technology is not readily available.

As far as SBA is concerned, the government's efforts are commendable (Hutton et al., 2018; World Health Organisation, 2018). As per data, 89.9 million toilets were built after the launch of SBA (Press trust of India, 2020; SBMG Phase-II Guidelines- Amendment to the Provisions with Respect to Construction of Community Sanitary Complexes (CSCs) Reg., 2020). Individuals are more aware of toilets, and hygienic practices and have seen the advertisements of toilets at various places as compared to pre-2014 (Dasgupta, 2020; Jayalakshmi, 2019). However, the local fieldwork and the policy-making should be continued to achieve zero cases of open defaecation in these local communities.

3.4. Respondents' choices and opinions on treated wastewater reuse

The following questions try to understand the choices and opinions of the respondents on the reuse of treated wastewater; Questions 6, 7, 8, 9, 11, 12, 13, 14 and 16 in Appendix A. These questions were asked to the households without toilets, hence the number of respondents in this section is thirty-seven.

3.4.1. Respondents' alignment with toilet adoption but reluctance to pay

Every respondent agreed that having a toilet in their household will elevate problems posed by open defaecation, as a response to Question 6. Academically as well, district-level data for the year 2011 shows the availability of toilets positively impacts the economic well-being of women (Gius & Subramanian, 2015). In continuance, Question 7 points out that though every respondent agrees that having a toilet is beneficial for their household, not every person wants to contribute more than the government's aid to construct toilets. Only twenty-seven out of thirty-seven, approximately 73% of the respondents, agreed to participate and pay more than the government aid to construct a toilet. When someone takes part in activities with others, like

the SBA and building toilets, it means they are joining in society and showing others how to do the same. Participating in social events makes one feel like the person is a valuable member of society, giving a sense of purpose and belonging (Bergland, 2016). However, in response to Question 8, when asked if the respondents would want to construct a toilet at their own expense, all the respondents disagreed (thirty-seven respondents in total).

Question 9 tests the people's awareness towards the financial constraints of toilet construction, as shown in Figure B.6 in Appendix B. Twenty respondents had no idea how much the construction costs, followed by a range between 0 to 10000 INR by nine respondents. People's attitude to willingly construct a toilet is discussed under the pretext of Question 11, and as shown in Figure B.7. Twenty-seven out of thirty-seven respondents refused to pay anything for toilet construction. The responders exhibited an attitude of entitlement.

3.4.2. Perceptions of Low-Cost Toilet Construction and Participation Intentions

Focus has been paid on people's attitudes towards the construction of a low-cost toilet and whether people would participate in the construction process, which is done under the pretext of Questions 12 and 13 (in Appendix A), respectively. About 78% (twenty-nine households) of respondents were hopeful that a low-cost toilet was trustworthy and worked for them if someone could provide a cheaper toilet facility. However, the remaining 22% (eight households) were apprehensive of such a facility citing that such a low-cost toilet implies poor quality as a response to Question 12. It was observed that not many individuals were passionate about contributing towards toilet construction. For example, in response to Question 13, twenty-eight out of thirty-seven respondents did not want to indulge in the toilet construction process while only nine respondents expressed their desire to participate in the toilet construction.

3.4.3. Navigating the challenges of sense of entitlement

It was noticed that citizens have self-entitlement in a way that they believe every service should be free of charge or available at no cost. In this study, people wanted to have a toilet in their households, preferably under a government scheme but rarely wanted to either contribute or help in the construction process. It is proposed that one way to deal with the sense of entitlement is to add value to the services provided to the people. Ramit Sethi (2017) mentioned that people value what they pay for (Sethi, 2017a, 2017b), so PWS should not be free.

Concerning this study, the sense of entitlement can be tapped to motivate people to make their demands for hygiene from the governments and the stakeholders. Communities and citizens can also be motivated through social campaigns (Withall et al., 2012). In this case, rather than publishing only about the usage and the health benefits of a toilet by the government, the government can also emphasize that people should have a right to have a toilet in their households and that they should approach government offices for help in building a toilet in their households. In that sense, when entitled individuals assess that they have a right to a service, the citizens might actually make efforts to get their rights.

3.4.4. Acceptance probability of toilets based on construction materials

Question 14 assesses the likelihood of acceptance of the toilets constructed from the various types of construction materials. Local materials found in an area were the most preferred option for constructing a toilet (Figure B.8). In this study, redstone and mudbricks were the readily available and the most preferred material, so they were easily accepted by the locals for toilet construction. Construction of the toilets using local materials would not only increase the acceptance of these toilets but would also strengthen the local economy. The construction sector maintains employment, pays wages, and contributes to local economies (Food, 2020; Moser & Feiel, 2019). As a result, the local economy will grow since the project's workers will have the income to spend at other nearby firms.

3.4.5. Public willingness to utilize excreta-derived pit humus

Question 16 studied people's willingness to use the pit humus from the excreta. Twenty-two respondents were comfortable using the pit humus either for all uses or for all uses except for the crops (Figure B.9, Appendix B). Psychological inhibition of the use of human faecal matter in agriculture has been reported as a big hindrance to the acceptance of pit humus obtained from a toilet.

3.5. Awareness versus enthusiasm in the toilet construction process

Table C.1. in Appendix C shows the results of the CTA between Question 9 and Question 12. As noticed from the table, 16 households or 43.24 percent of the total responses have no idea how much a toilet building costs them, and they are enthusiastic that it works best for them if someone can provide the toilet facility at a lower price. On the other hand, only 2 households, or just 5.40 percent of the total responses are enthusiastic about a fast-to-construct toilet. This tells that people are more likely to help in the toilet building process when they have no idea how much a toilet building will cost them.

3.6. Attitude of the respondents towards investment in the toilet building process versus using the toilet in its full capacity

Table C.2. in Appendix C shows that 33 households or 89.18 percent of households have a polarised view on using pit humus. They will either use it or would not use it at all. Only 4 households or 10.82 percent of households are willing to use the pit humus for growing non-human consumption crops only. In addition to this, when the households have invested money in the toilet-building process (rows 2 to 4), they are more inclined to use the pit humus. In that case, 3 households are not willing to use the pit humus, as compared with 7 households who are willing to use the pit humus either fully or with constraints. This is because those who have paid for the services are more inclined to use them because they have invested in them. Since

the people have a personal stake in the service's success, they might be more apt to use it and benefit from it.

3.7. Consumer behaviour towards paying for the toilet building service

Table C.3. displays the relationship between Question 7 and Question 11. 23 households or 62.1% of total responses have opted for a “no” in both the questions, and 7 households or 18.9% of total responses have opted for a “yes” in both cases. This means that 81% of total cases have opted for the same cases in both questions. Those households are either not interested to pay for the toilet services at all or might want to pay for the same. However, there are 3 responses or 8.1% of people who opted for a “yes” in Question 7 but a “no” in Question 11. Hypothetically those households would pay money but, they would prefer not to. The reason could be well engraved in how the human mind works. The human mind is not always logical and is calculative (*The Oxford Handbook of Rationality*, 2004). It seems that those households have not made their decision yet and that there is a second thought behind their minds. There could be a thought that in the future if they can benefit, they can change their minds to paying for the service. Those respondents must have realised that Question 7 is hypothetical, and so have answered that question at that time. Since the respondents are not 100 percent sure of the response, they have had given an answer even if it might not align with their beliefs. These responders must have been under the impression that if a real question comes, they would answer that then.

Four households have declined to pay in the hypothetical question but ended up actually paying for it. People may initially deny paying due to social pressure or expectations. However, when faced with a situation where they can make a difference for someone else, they may feel compelled to pay despite their initial reluctance. As per research, there is a strong and subversive normative message hidden within the statement "Many people are doing this undesirable behaviour", under the effect of social pressure (Cialdini, 2003). Normative

messages are successful at promoting "desired" pro-environmental behaviour if a majority of people engage in it (De Groot, 2022). To maximise the effectiveness of normative appeals, descriptive norms (what people usually do) and injunctive norms (what people usually approve or disapprove of) must be in alignment⁶¹. People's motivations and reasons for paying for a service can be complex and multifaceted. Hence, each individual's unique circumstances and perspectives should be considered when trying to understand consumer behaviour.

3.8. Efficacy of the advertisements

Table C.3. analyses the relationship between Question 15 and Questions 11 and 12. Though, in Question 15, the responses are "Government Dispensaries/Hospitals", "Television/Mobile phones", "Village walls", "Schools", and "Never heard of one"; for comparison, all these responses have been compiled to only two categories: if the respondent has seen an advertisement or if he has not seen any.

Interestingly, in the first analysis of Question 15 with Question 11, people who have never seen an advertisement are more likely to pay for the services (9 households or 42.85% of respondents in that category as compared to 12 households or 57.14% of respondents in that category). Among the households who have seen an advertisement, 2 households or 12.5% of respondents in that category would pay for the service as compared to 14 households or 87.5% who are not interested in paying for the service. In the second analysis wherein Question 15 has been analysed across Question 12, no trend is evident. Though it might be expected that people who saw an advertisement would be more eager to pay for the service or believe that a low-cost toilet would be good for them, the data reveals another set of information. It can be inferred that the advertisements are not as effective as they should be. During the survey, it was observed that the locals are unable to relate to the advertisements and may not understand them due to lack of education. There is also no call to action in the advertisements, leaving people clueless about using the SBA scheme. Though SBA has been proven to be a promising welfare

scheme and toilets are found in the localities, there are households who are unaware of this PWS. If more work is done on advertisements, and the findings of this study are taken into account, then those households can be addressed as well. The points raised would not only assist in improving the SBA but would also assist in creating PWS and policies worldwide.

4. Conclusion

There has been an influx of money and resources to promote safe sanitation and hygiene worldwide, yet 494 million people still defaecate in the open (World Health Organisation, 2022). This concentrated research has inadvertently brought up some conclusions regarding the attitude of low-income families towards the government schemes of toilet construction.

1. The efforts of the Indian government are commendable under the SBA Scheme. Open defecation still occurs due to poverty and lack of toilets.
2. There are community toilets, but many families do not use them because the toilet is not in their neighbourhood and the community toilets are not maintained well.
3. To increase the acceptance of toilets in low-income communities, locally available construction materials are preferred and accepted. This is also anticipated to strengthen the local economy.
4. Locals in low-income communities display a high sense of entitlement. They want to have a toilet in their households but rarely want to contribute to the toilet-building process or pay for the services.
5. People unaware of how much a toilet building will cost them, are more apt to participate in the construction process.

6. People have a polarised view of using the pit humus obtained from the toilets. They will either use the pit humus in all forms or would not use it at all. There are no intermediate perspectives.
7. Those who have invested in the toilet building process are more likely to use the services fully, including the full utilization of pit humus from the toilets, hence increasing the acceptance of the toilets.
8. There have been instances, though few, when people would pay for the services under social pressure, feelings of guilt, or fear.
9. Advertisements related to SBA are ineffective.

4.1. Making urban sanitation more accessible

There have been studies on transforming the behavioural norms of rural populations to revitalize the PWS through depiction (highlighting the dignity and cultural enrichment that toilet facilities can bring to households), demonstration (organizing live toilet demonstrations for easy operation and maintenance), and divulsion (raising awareness about health risks of open defaecation and promoting low-cost toilet construction) (Anderson et al., 2022; Sriroop Chaudhuri & Mimi Roy, 2018; *The “5Ds”*, n.d.). Adding to these points, through this study, it is proposed that religious places of worship can be used to promote hygiene practices and notify government schemes to the people where technology is not much evident. These PWS should not be accessible at no cost. For example, to reduce the ‘feeling of entitlement,’ a small sum may be set aside for installing toilets. To increase toilet usage in entitled communities, it is proposed to tap into their sense of entitlement by running social campaigns that emphasize having a toilet as a basic right. For a better understanding of wastewater reuse perspectives and acceptability, knowledge and prior experiences, which can be obtained through various information-sharing channels, are essential. The primary means of informing the public is through the media (such as television, radio, and newspapers); nevertheless, the number of

educational programmes should be increased. As far as advertisements are concerned, people prefer real-world examples of the product or service to the generic stock photos that everyone else uses (Gauri et al., 2023; Marcy, 2023). Actual pictures could be utilised to stir up an emotional response (Murray, 2013). In addition, there should be a compelling call to action (Campbell, 2018; McCormick, 2023).

4.2. Informing policy formulation and implementation

Experts working in the fields of public health, sanitation and policymaking may find approaches and answers to the technical and scientific difficulties involved with excreta reuse and management engaging and interesting. Such in-depth and subsequent studies contribute significantly to our understanding of human perceptions, which are often ignored when formulating policies or introducing PWS. Furthermore, fixing some of the challenges discussed here would benefit the public's understanding through improved techniques and aid in drafting public policies and schemes.

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Navigating through the sense of entitlement to promote in-situ hydrochar acceptance

1. Introduction

Examining the challenges of community sanitation is important. There is also a need to address the growing issue of sewage treatment, and so, to explore sustainable solutions to these problems. The focus on societal perspectives and difficulties related to sanitation practices, especially in slum areas, helps us understand public health and sanitation issues. The key is to tackle these sanitation challenges in a way that is practical and long-lasting for communities. This prepares a discussion on Sewage Sludge (SS) management, and includes the possibility of hydrothermal carbonization (HTC) as a revolutionary SS solution, providing a viable path for energy production, environmental restoration, and sustainable resource use.

1.1. Hydrothermal Carbonisation

Hydrothermal carbonization (HTC) is a thermochemical process that uses heat and pressure to convert biomass and organic waste (Ahmad et al., 2018). HTC of sewage sludge from wastewater treatments can reduce waste volumes, transforming sludge into valuable products (Scrinzi et al., 2023). HTC is receiving increasing attention as a sustainable thermochemical process for the conversion of wet biomass into a solid peat-like product, known as hydrochar (HC). Thermochemical treatments are often preferred over biological processes, due to their short reaction times and high conversion efficiencies (Zhang et al., 2014). Biochar is obtained from the thermochemical conversion of biomass in an oxygen-limited environment, through a pyrolysis process. However, materials with high moisture content (>30%), like vegetable

wastes, sewage sludge, animal wastes, and algae can be dried only by energy-intensive techniques (Mani et al., 2006; Savage et al., 2010). HTC operates in sub-critical water at temperatures between 180 and 280 degrees Celsius, at autogenous pressure (up to 2 MPa), with the generation of hydrochar, a water-soluble organic fraction (sugars, acetic acid, and other organic acids) and a gas fraction (mainly CO₂). The cellulose content of primary sludge from sewage treatment is about 7.1%, based on total solids (Glińska et al., 2020). The main transformations occurring during HTC are based on hydrolysis and dehydration of cellulose, hemicellulose, and lignin to monosaccharides and disaccharides which, in turn, are dehydrated, hydrolyzed and decarboxylated to give intermediate fragments whose re-condensation leads to the hydrochar formation. Besides the expected use as fuel, hydrochar is a carbonaceous matrix that may find an application in several fields such as energy storage (Fakkaew et al., 2018), manufacturing of materials (activated carbons, electrodes or composites) (Tekin et al., 2014) and agriculture (Wu et al., 2018). The use of biomass to produce chars could offer interesting opportunities, especially when feedstocks do not have any economic value and do not compete with the food crops for land requirements. However, crop residuals left in the field help in the restoring of soil properties, reducing the external inputs, as well as treating sewage sludge that could be used as sustainable fertilizer. Hence, overuse of such by-products for energy generation purposes would be deleterious for the environmental life cycle. In addition to the increasing worldwide research activity at the laboratory scale, a few industrial applications of the HTC process, based on different reactor configurations, have been developed recently, owing to the popularity and the usefulness of hydrochar (Funke and Ziegler, 2010; Hitzl et al., 2015; Kambo and Dutta, 2015; Kumar et al., 2018; Libra et al., 2011; Pavlovič et al., 2013).

1.2. Adoption of hydrochar_ a way forward

Although there are already a variety of recycling initiatives available to the public, adoption of those is low (Chertow, 2009; Valenzuela-Levi et al., 2021), as is the case in adopting and

exploiting SS-derived hydrochar for energy harvesting from recycled material. Therefore, given that people are the actual implementers and stakeholders in this world, a better understanding of their motivations for recycling SS could assist policymakers in developing expanded policies and carbon emission abatement (CEA) programs to improve sustainability (He et al., 2016). In addition, according to the authors' knowledge, no studies have been reported examining the acceptance of hydrochar as a recycled product suitable for use as a fuel source.

1.3. Toilets producing hydrochar

Several companies and start-ups are contributing to onsite sewage waste management. As shown in Figure 4, The Blue Diversion Autarky toilet is an innovative sanitation system designed to operate independently of traditional water and wastewater infrastructure (Sutherland, Reynaert, Dhlamini, et al., 2021; Sutherland, Reynaert, Sindall, et al., 2021). It separates and treats water, urine, and faeces on-site, utilizing modules for water recycling, nutrient recovery, and pathogen inactivation. The system employs gravity-driven membrane filtration, activated carbon, and electrolysis for water treatment, while urine is pretreated to remove odours and pathogens, and faeces are processed via hydrothermal oxidation. This modular approach allows components to function independently or within other sanitation systems.

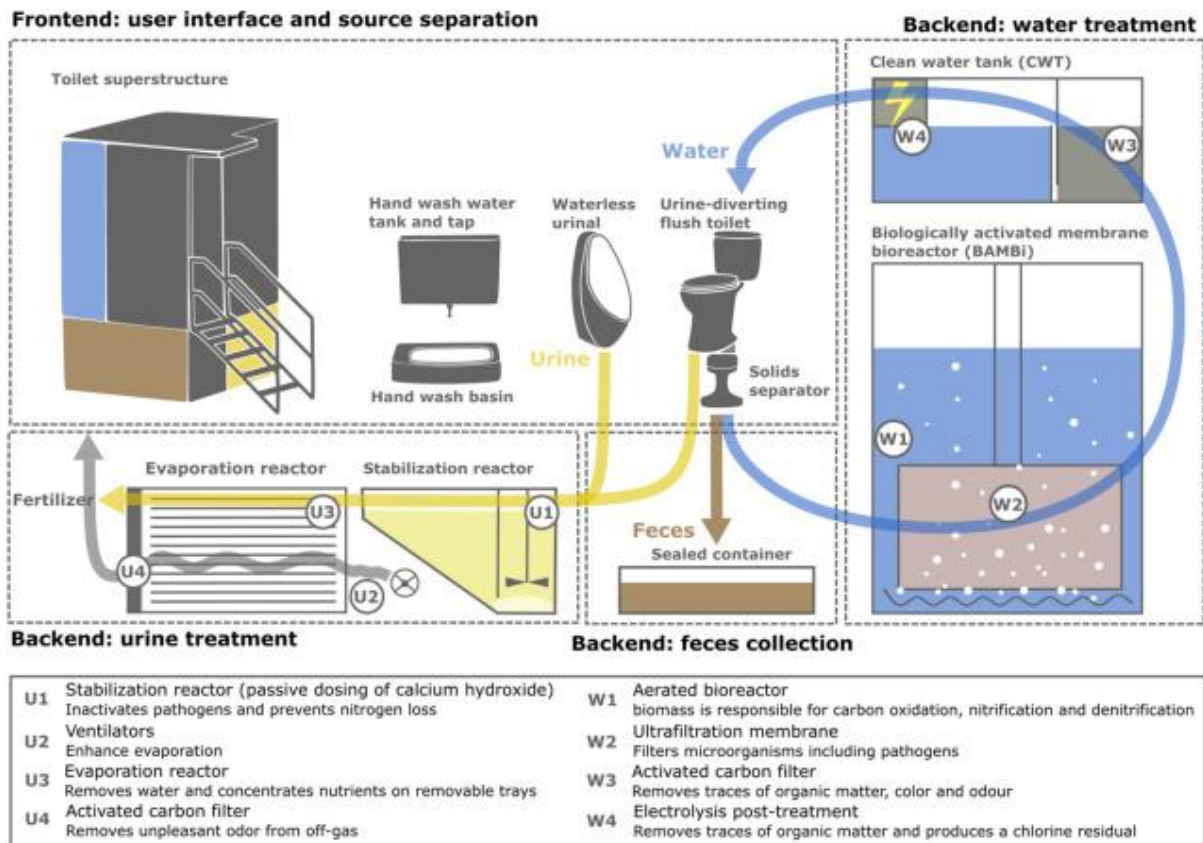


Figure 4: Schematic representation of the Blue Diversion Autarky Toilet (BDAT), with the front-end (toilet superstructure including a urine-diverting flush toilet with solids separator, waterless urinal, handwash water tank with tap and handwash basin) and backend technologies (water and urine treatment) (Sutherland, Reynaert, Dhlamini, et al., 2021).

Several companies like Greenport Toilets (Sturzenegger, 2017) and BDAT are working on toilets that produce in-house char, or hydrochar. The biochar reactor in these toilets holds the capacity to address the global sanitation crisis, which affects over 2.5 billion people worldwide, including a quarter of India's population. These toilets:

- Processes human solid waste without requiring power, water, or sewers
- Converts waste into char, a pathogen-free, and odour-free soil amendment
- Can process waste from thousands of people daily
- Costs less than 5 cents per person per day

This solution shows promise for developing nations by reducing human-borne pathogens, lowering food production costs, and improving soil content, in addition to tapping into the sense of entitlement that some communities hold.

This innovative approach to waste management offers multiple benefits, including improved sanitation, agricultural enhancements, and potential entrepreneurial opportunities through hydrochar sales (Brian von Herzen, 2014).

1.4. Theory of Planned behaviour, *Introduction of*

To pinpoint the psychological variables affecting people's intentions and behaviours, the theory of planned behaviour (TPB) is most frequently used (Ajzen, 1991). It is a socio-psychological approach that states that an individual's decisions are influenced mainly by specific objective elements, such as knowledge, resources, and opportunities, rather than exclusively by their subjective desires. According to the TPB, one's intention is determined by three socio-psychological constructs, including attitude (positive or negative evaluations concerning engaging in a particular behaviour), subjective norm (social pressures on engaging in a particular behaviour), and perceived behavioural control (perceptions about one's capabilities to engage in a particular behaviour based on his or her experience and resources) (Ajzen, 1985). The intention is the primary driver and motivator behind actual behaviour (Ajzen, 1985, 1991).

The TPB has been used to research issues such as low-carbon agriculture (Yazdanpanah & Forouzani, 2015), household recycling (Kaiser[^] et al., 2003), green purchase decisions (Zhang & Dong, 2020), low-carbon tourism (Bamberg & Schmidt, 2003), and other pressing issues like agriculture (Jiang et al., 2018). The TPB has also been used to analyse innovative technology adoption decisions and intentions for adapting to climate change (Truelove et al., 2015). This theory offers an essential theoretical framework for forecasting the intentions and

actions of citizens (Bosnjak et al., 2020; Godin & Kok, 1996). Thus, it can offer great insights into the psychological factors that drive citizens' intentions to use SS in the form of hydrochar (HSS). In addition, the study undertakes cross-table analysis (CTA) (in Chapter 5) which is a method for simultaneously presenting the frequency distribution of two or more variables (Dass, 2010).

1.5. Cross table analysis, *Introduction of*

Cross-table analysis (CTA) is a method for simultaneously presenting the frequency distribution of two or more variables (Dass, 2010). CTA has been used in various kinds of studies to reveal information about the relationships between the values of the two variables. For example, scientists have conducted CTA to find out the relationship between temperature or humidity levels and dengue event cases (Alkhalidy & Basu, 2022). Related research employed CTA to examine health problems and solid waste management in the Sawaba community in Ghana. According to the study, and as per the CTA of disease contraction and distance from final disposal sites, people who live close to open dump sites are more likely to get associated illnesses including malaria and skin infections, among others, as a result of poor waste disposal (Suleman et al., 2015). However, Suleman et al. (2015) did not study the behavioural pattern of the inhabitants using the CTA. CTA on human behaviours is largely unexplored.

In this study, CTA has been performed additionally among the constructs (Attitudes, subjective Norms, perceived behavioural Control, and intention) to explore the intricacies of human behaviour, and the relationship between the two constructs. The study aims to have an in-depth discussion on reasons for human behaviour, adding to the findings of the TPB in the previous chapter. The findings of this study are also expected to aid policymakers worldwide in modifying current regulations and creating carbon emission abatement programs that provide incentives for the use of HMSW.

2. Research flow

This study starts with the data collection from the quantitative survey, and the raw data is compiled after that, as shown in Figure 5. Two tests are done simultaneously: Shapiro Wilk test to check for normal distribution and Cronbach's α test to check for consistency and reliability of the data. Failing of the Shapiro-Wilk test (W not close to 1) implies that the data is invalid to conduct SEM because it does not follow the normal distribution. Failing of Cronbach's α test (Cronbach's α value < 0.60) implies that the data is not consistent and reliable, in that case, it is advised to get more data by conducting additional qualitative surveys. When both tests are passed (W closer to 1, for the Shapiro- Wilk test and Cronbach's α value ≥ 0.60 , for Cronbach's α test), the study proceeds to the SEM using the concept of TBP, and simultaneously conducts CTA to understand the correlation between different variables.

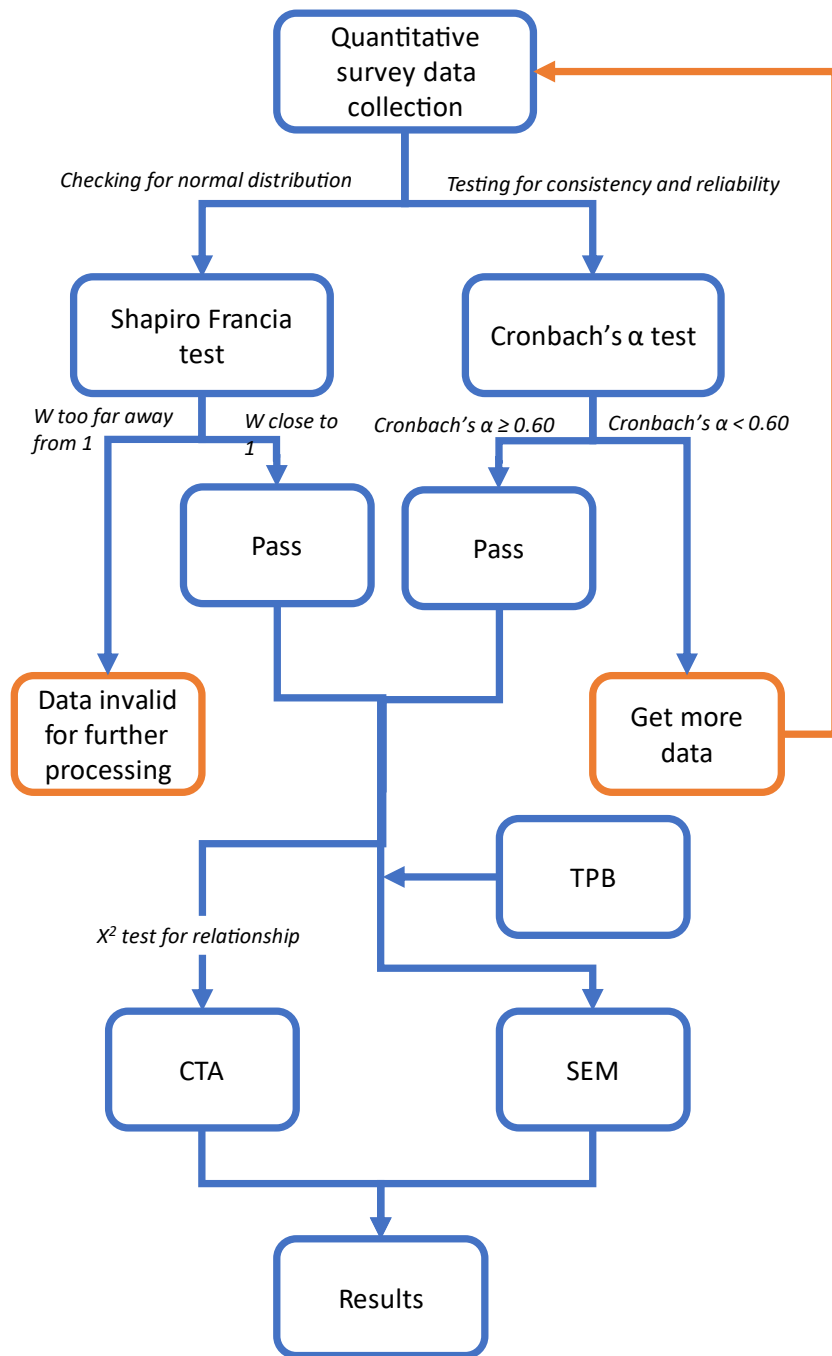


Figure 5: Flowchart depicting research flow. Abbreviations used in this flowchart are as follows: TPB for the theory of planned behaviour, CTA for cross-table analysis and SEM for structural equation modelling.

3. Research methodology and data collection

This section starts with the sampling and the data collection. Then, it discusses the sample's demographic characteristics and checks the consistency and the validity of the dataset through Cronbach's α test and the Shapiro-Wilk test so that the data can be used for further modelling. The TPB is then discussed along with the three hypotheses, and the concept of SEM is discussed, which is to be used in then further sections to find out the impact of psychological factors on citizens' intentions.

3.1. Sampling and data collection

The data for this study was obtained via online and a face-to-face questionnaire survey in Jaipur, India, from June to August 2022. The citizens were chosen randomly, through WhatsApp status blasts or by contacting the local fitness studios and gyms, which see the membership of people of all ages and various socio-economic backgrounds. It is important to note that people of all backgrounds in India, whether rich or poor, have a very high probability of owning a cell phone, thus making it possible for the surveyor to get reliable data from every background. India has over 700 million smartphone users, including 425 million in rural areas, as of January 2023 (Ayushree Gupta & Siddhant Sachdeva, 2023). Each data entry/ respondent is marked by his/ her cell phone number, which is unique to prevent data repetition.

The questionnaire's final iteration had three sections: 1) the respondents' demographic and socio-economic information; 2) an explanation of the HSS; and 3) the respondents' responses to the related questions based on the TPB. A final sample of 74 responses was analysed after 76 responses were received in total, wherein two responses had missing or conflicting important information and were disqualified. The study was stopped at 74 responses as soon as responses passed the validity and the reliability test (section 3.3). The final section of the questionnaire was scored using a five-point Likert scale, with the five responses being

“1=strongly disagree; 2=disagree; 3=neutrality; 4=agree; and 5=strongly agree.” In addition, based on several pertinent research (Fielding et al., 2008; Folse et al., 2010; Oliver & Rosen, 2010), five questions were designed to test the observed variables of attitudes, three for subjective norms and three for perceived behavioural controls and HSS intentions. The actual survey sheet is displayed in Appendix D.1 (English version) and Appendix D.2 (Hindi version).

3.2. Demographic characteristics of the sample

Out of 74 respondents, 47 were male, and 27 were female. This unequal participation of the genders can be described by the fact that the society in the concerned region is still patriarchal (Hasan & Agarwal, 2019; Vikalp Sansthan, 2020). However, this unequal ratio does not seem to influence the analysis, as is shown in the next section. The respondents in the sample ranged from 19 to 64, with a mean age of 28.29 years. The mean is similar to the census median age in India in 2020, which was 28.4 years (Worldometer, 2022). The data collected and India’s actual distribution of urban residents agree. So, for the subject of this study, this is a typical and representative sample.

3.3. Consistency and the validity of the dataset

The formal survey data should be consistent, reliable, and tested by Cronbach’s α values. Cronbach’s α measures the internal consistency, or how closely connected a group of things are to one another. It is regarded as a gauge of scale dependability. The average inter-correlation between the test items and the total number of test items can be used to calculate Cronbach’s α . Cronbach’s α formula is as follows:

$$\alpha = \frac{N\bar{c}}{\bar{v}+(N-1)\bar{c}} \quad (1)$$

where N is the total number of items (in our case, total sample entries, which is 74), \bar{c} is the average inter-item covariance among the items and \bar{v} is the average variance. Equation (1)

shows that Cronbach's α increases as the number of items increases. Furthermore, the α will be low if the average inter-item correlation is low. Cronbach's α rises with an increase in the mean inter-item correlation (holding the number of items constant). When Cronbach's α value is between 0.60 and 0.70, it indicates acceptable reliability; when it is between 0.70 and 0.80, it indicates good reliability (DeVellis & Thorpe, 2021; UCLA: Statistical Consulting Group, 2021).

Secondly, SEM assumes that the data follows a normal distribution (Donaldson, 1999; Kumar & Upadhaya, 2017). A statistical test based on sample data, the Shapiro-Wilk test determines whether a population is normally distributed. The Shapiro-Wilk test was proposed by S. S. Shapiro and M. Wilk in 1965 (Shapiro & Wilk, 1965). The Shapiro-Wilk value is calculated by W value calculated from the following formula (equation (2)):

$$W = \frac{\sum_{i=1}^N a(i) * x(i)^2}{\sum_{i=1}^N (x(i) - \bar{x})^2} \quad (2)$$

wherein W is the variance test statistic for testing complete samples for normality. The null distribution of W is approximated by an empirical sampling study. $x(i)$ is the i-th ordered value from the size N sample while \bar{x} is the mean of all the $x(i)$ s. The values $a(1), a(2), \dots, a(i), \dots, a(n)$ incorporate the normal order statistics, the structure of data around the best-fit line (variance – covariance) and normalize for the scale of the data from the estimation of Q-Q slope for the calculation of Shapiro-Wilk test..

3.4. Theory of planned behaviour (TPB)

Icek Ajzen proposed TPB in 1985 to forecast human behaviour. It is a psychological theory that connects behaviours and actions. According to the theory, an individual's behavioural intentions are shaped by three fundamental factors: attitude, subjective norms, and perceived behavioural control (Ajzen, 1985). Citizens' intent to act will typically be stronger when they have favourable opinions of specific conduct, experience greater social pressure to engage in

the behaviour, and believe they have more resources, opportunities, and fewer perceived obstacles. In the context of this research, citizens' intentions to use HSS will be higher when they have a favourable opinion of HSS, understand that HSS is the behaviour that society encourages, and perceive the viability of HSS in their own capabilities, such as labour, capital, and technology. Intention is a critical component of the TPB because the theory says that if a person really wants to do something, they're more likely to actually do it. By understanding what people intend to do, researchers and professionals can predict how likely it is that a certain behaviour will happen, even without observing the behaviour directly. This is valuable for a wide range of research and practical purposes. Intentions help connect an individual's beliefs, attitudes, and perceptions to their actual behaviour, explaining how their thoughts lead to their actions (Fielding et al., 2008; Yazdanpanah & Forouzani, 2015).

Similarly, Wauters et al., (2010) defined "attitude" as the citizens' favourable or unfavourable assessments of activity (Wauters et al., 2010). According to this study, citizens will be more likely to use hydrochar if they believe doing so will benefit them and the environment. The term "subjective norm" describes the societal constraints citizens feel about recycling SS, particularly those based on the views of the influential people in their community. Citizens are more likely to adopt environmentally beneficial products like SS in the hopes of gaining social acceptance when they believe it has the support of influential individuals or opinion leaders, such as village administrators, highly educated neighbours, and wealthy residents in the community (Lin, 2013; Power et al., 1988; Vaughan, 1995; Yang et al., 2020; Zhang et al., 2017). Citizens' perceptions of challenges and opportunities in HSS based on their capabilities, including labour, capital, and technology, are referred to as "perceived behavioural control". To some extent, citizens' intentions to take action will be encouraged or hindered by perceived behavioural control (Lin, 2013; Zhang et al., 2017). Therefore, it will be easier for them to use HSS if their perceptions are favourable.

To test if the TPB model is applicable in this situation, we have put up the following three hypotheses:

Hypothesis 1 (H1): Citizen's intentions to use HSS are positively impacted by their attitudes.

Hypothesis 2 (H2): Citizens' intentions to use HSS are positively impacted by their subjective norms.

Hypothesis 3 (H3): Citizens' intentions to utilize HSS are positively impacted by their perceptions of behavioural controls.

3.5. Structural Equation Modelling (SEM)

Structural Equation modelling or SEM is a multivariate method employed in scientific studies to test and assess multivariate causal relationships. The TPB was used to guide the design of this study, which used attitudes, subjective norms, and perceived behavioural controls as independent factors and the citizens' intentions as a dependent variable. The logical relationships between these constructs were examined using SEM, which enables the simultaneous estimation of the relative importance of citizens' attitudes, subjective norms, and perceived behavioural controls in the TPB model. Given the challenges in measuring unobserved latent constructs and subjective measurement errors, SEM was used to analyse the logical relationships between these constructs (Bleakley & Hennessy, 2012). There are three major equations used in the calculation of SEM (equations (3), (4) and (5)):

$$X = \Lambda_x \xi + \delta \quad (3)$$

$$Y = \Lambda_y \eta + \varepsilon \quad (4)$$

$$\eta = B \eta + \Gamma \xi + \zeta \quad (5)$$

The term X is an exogenous latent variable. Also known as the independent variable, it causes fluctuations in the values of other variables in a model. This reflects the indices of citizens'

attitudes, subjective norms, and perceived behavioural controls towards HSS. ξ is the exogenous observed variable and is measured by the researcher. ξ is not controlled by other variables in the system. It refers to attitudes, subjective norms, and perceived behavioural controls. Term Y is the endogenous latent variable vector. Also known as the dependent variable, Y is influenced by the exogenous variables, either directly or indirectly. Here, it represents the indices of citizens' intentions in HSS usage. The term η is the observed endogenous variable. This variable is measured by the researcher and is affected by other variables in the system. Here, η refers to the intentions. The terms Λ_x and Λ_y are the correlation coefficient matrices representing the relation between the exogenous latent variables, the endogenous latent variables, and their corresponding observed variables. δ and ε are the error vectors. δ and ε measure error vectors of the observed exogenous and endogenous variables, respectively. The coefficient matrix is represented by the term B which represents the relationship between some endogenous latent variables and other endogenous latent variables, reflecting the mutual influences among the endogenous latent variables. Γ is the structural coefficient matrix. It represents the relationship between the endogenous and the exogenous latent variables, reflecting the path coefficients of the exogenous latent variable X on the endogenous latent variable Y . The last term is the error term ζ , representing the random error term of the structural equation. Based on these constructs, it is meant that equation (3) tests the relationships between latent variables and their corresponding observed variables, including the exogenous latent variable equation. Equation (4) tests the relationships between latent variables and their corresponding observed variables, including the endogenous latent variable equation. Equation (5) tests the causal relationships between the exogenous latent variables and the endogenous latent variables which are also known as path analysis.

3.6. Chi-square test (χ^2 test, *Theory of*)

The Chi-square test of independence is a statistical method used to determine the relationship between two categorical or nominal variables (Pearson, 1900). Its purpose is to assess the likelihood of the observations under the assumption that the null hypothesis holds true.

To conduct the Chi-square test of independence, two variables in question are required. Before moving on to the cross-table analysis to observe the relationship between these variables, it is important to establish the association between the variables. In this study, the variables are the measured items, i.e., AT1, AT2, and so on. Determination of the relationship begins with defining the null hypothesis and alternative hypothesis. The null hypothesis posits that there is no relationship between the variables, while the alternative hypothesis suggests that there is indeed a significant relationship.

The chi-squared test aids in determining whether a substantial difference exists between the expected frequencies and the observed frequencies across different categories. It provides the probability of independence between the variables. Upon performing a chi-square test, a p-value is obtained, which indicates the significance of the test results. To compute the p-value, the degrees of freedom (DF) and the chosen alpha level are defined. DF can be calculated as the number of categories minus 1, and the alpha level is commonly set at 0.05 (5%).

The distribution of χ^2 with $(r-1)(c-1)$ degrees of freedom is represented in an empirical table where r denotes the number of rows and c represents the number of columns in the two-way table. In our study, referring to Table 3.1, r is 5, and c is 5, therefore DF is $(5-1)(5-1) = 16$.

Table 3.1: General format for the Chi-square test and CTA (unit: number of respondents).

	Item 1
--	---------------

		Likert scale value 5 for item 1	Likert scale value 4 for item 1	Likert scale value 3 for item 1	Likert scale value 2 for item 1	Likert scale value 1 for item 1
Item 2	Likert scale value 5 for item 2	Cell 5-5	Cell 4-5	Cell 3-5	Cell 2-5	Cell 1-5
	Likert scale value 4 for item 2	Cell 5-4	Cell 4-4	Cell 3-4	Cell 2-4	Cell 1-4
	Likert scale value 3 for item 2	Cell 5-3	Cell 4-3	Cell 3-3	Cell 2-3	Cell 1-3
	Likert scale value 2 for item 2	Cell 5-2	Cell 4-2	Cell 3-2	Cell 2-2	Cell 1-2
	Likert scale value 1 for item 2	Cell 5-1	Cell 4-1	Cell 3-1	Cell 2-1	Cell 1-1

The chi-squared test is done to check if there is any difference between the observed value and the expected value. The formula for chi-square can be written as;

$$\chi^2 = \sum (O_i - E_i)^2/E_i \quad (6)$$

where O_i is the observed value and E_i is the expected value. E_i is calculated as the row total ($\sum r_i$) * column total ($\sum c_i$), divided by the grand total, i.e., the number of respondents which is 74 in this study. To calculate the p-value for the chi-square test, Jamovi software has been used. The steps for the same in the software have been shown in Appendix J.1.

For a Chi-square test, a p-value that is less than or equal to the significance level indicates there is sufficient evidence to conclude that the observed distribution is not the same as the expected distribution. It can be concluded that a relationship exists between the categorical variables.

3.7. Cross-table analysis (CTA, *Theory of*)

Once a relationship is established between the two variables, the study proceeds to the cross-table analysis to explore the trend between those two variables. A cross-tabulation is a two or more-dimensional table that counts the proportion of respondents who meet the criteria listed

in the table's cells. Cross-tabulation is, in general, used with categorical variables or data, such as information that may be broken down into mutually exclusive groups (Dass, 2010; Qualtrics.XM, 2023).

While performing CTA, each value of the two items under consideration is matched with each other. For example, the five Likert values of item 1 will be matched with the Likert values of item 2. This makes a 5 X 5 table. The value in each cell is then divided by the total number of respondents, this tells the percentage of the number of respondents who have chosen that particular combination. Table 3.1 depicts the format of the CTA to be used in further sections.

The first row in Table 3.1 shows item 1 and the first column is item 2 to be analysed across with item 1. The second row is a division on the 5 Likert values for item 1. The same is for the second column for item 2. The rest of the cells depict the value of particular cases, for example, cell 4-5 will show the number of respondents who choose Likert value 4 for item 1 and Likert value 5 for item 2. All remaining cells follow the same pattern.

Heat mapping has been done to visually represent the CTA results. A heat map depicts a comparative view of a dataset. In the dataset, the colour scale is red to white. Cells in the red have high values and the zero value cells are in the white colour. Dataset visualised in the form of a heat map show which analysis is highly concentrated at a point and which are more uniformly distributed.

In this study, CTA is performed on those items which are mutually exclusive, and which have a standard deviation greater than 1. Additional analysis has been attempted for the items having the highest and the lowest average items.

4. Results

This section constitutes the measured items (attitude, subjective norm, perceived behavioural control, and intention) assertions and descriptive statistics. After performing the consistency and the validity test on the data, the section heads on to the SEM, which includes confirmatory factor analysis and path determination and relation among the measured items. CTA is performed thereafter.

4.1. Item measurements

Three questions each for subjective norms, perceived behavioural controls, and HSS intentions were created, and five questions for attitude assessment. Table 3.2 displays the specific statements and descriptive data for the measured items.

Table 3.2: Measured items' assertions and descriptive statistics, representing attitude, subjective norm, perceived behavioural control, and intention.

Construct	Item	Statement	Mean	Standard deviation
Attitude (AT) (Fielding et al., 2008; Jiang et al., 2018)	AT1	HSS can increase my economic income.	3.72	0.82
	AT2	HSS production will alleviate air pollution in rural and urban areas.	4.05	0.72
	AT3	I support the acceptance of HSS contributing to human health.	4.07	0.78
	AT4	The utilization technologies of hydrothermal carbonization/ hydrochar are environmentally friendly.	4.16	0.74
	AT5	HSS is necessary to make our environment sustainable.	4.09	0.86
Subjective Norm (SN) (Fielding et	SN1	My peer group will think positively of me when they get to know that I am using HSS products.	3.80	1.01

al., 2008; Jiang et al., 2018)	SN2	Highly educated neighbours' opinion has a great influence on my decision about hydrochar.	3.27	1.20
	SN3	Wealthy and influential leaders would approve of the behaviours of HSS use.	3.64	0.94
Perceived Behavioral Control (PBC) (Jiang et al., 2018; Oliver & Rosen, 2010)	PBC 1	I have enough money to adopt the technologies of hydrothermal carbonization/ hydrochar products.	3.91	0.89
	PBC 2	I can easily get technical support in HSS from industrial technical experts if and whenever I want.	3.47	1.01
	PBC 3	I am confident that I can quickly learn and master the technologies of the usage of HSS.	3.93	0.73
Intention (IN) (Folse et al., 2010; Jiang et al., 2018)	IN1	I intend to learn the utilization technologies of SS.	3.89	0.91
	IN2	I am willing to reuse SS to protect the environment and to be in harmony with nature.	4.04	0.87
	IN3	I would like to reuse SS to conform to the future development trend of low carbon emissions.	4.04	0.92

The responders had a generally positive opinion of utilizing HSS. As shown in Table 3.2, the mean score for the five attitudes ranged from 3.72 to 4.16. Since the valuation is done on the Likert scale ranging from 1 to 5, the mean reference value is 2.5. Additionally, the respondents reported high levels of attitude when using HSS and somewhat high intentions. The mean range across all items measuring perceived behavioural controls and subjective norms is 3.27 to 3.93. The highest mean value among all the items is 4.20, shown in item AT4 (Table 3.2), wherein the respondents believe that the utilization technologies of HSS are environmentally friendly. This result shows that the citizens understand the importance of our environment and are

hopeful that a technology like HSS will reduce their carbon footprint. The lowest standard deviation is 0.72 in item AT2 in which the respondents believe that HSS production will alleviate air pollution in rural and urban areas. The three items used to gauge intents had the lowest mean of 3.89, and the respondents also had a good intention to utilize HSS.

4.2. Consistency and Validity test

The first step in analysing data is to test the consistency and validity of the formal survey data. Cronbach's α test was performed to test the validity and reliability. It was done using a free software called Jamovi (version 2.2.5). Jamovi is a free and open-source computer program for data analysis and performing statistical tests. The results showed that Cronbach's α value for the citizens' attitudes, subjective norms, and perceived behavioural controls combined is 0.863, which is of very high grade. The Cronbach's α value of all the observed items under the intention to use HSS is 0.897. All these values reveal good internal consistency.

The Shapiro-Wilk test was used to calculate the normal distribution of each item through the same software Jamovi. Every case's α value (significant threshold) is kept at 0.05. As shown in Table 3.3, the Shapiro-Wilk W value of each item is close to 1, implying that the data follows a normal distribution.

Table 3.3: Shapiro-Francia W-value of each item set (α kept as 0.05)

Item	W value
AT1	0.864
AT2	0.823
AT3	0.802
AT4	0.816
AT5	0.820
SN1	0.870
SN2	0.908

SN3	0.881
PBC1	0.858
PBC2	0.890
PBC3	0.832
IN1	0.825
IN2	0.743
IN3	0.814

4.3. Structural Equation Modelling

The software “Jamovi” (version 2.2.5) was used to conduct the confirmatory factor analysis, and then the SEM (Epskamp et al., 2022; Rosseel, 2012; *Useful Tools for Structural Equation Modeling [R Package semTools Version 0.5-6]*, 2022). The Jamovi project/ software aims to provide a free, open, and user-friendly statistical platform that can deliver the most recent advancements in statistical methods (Love et al., 2020). Confirmatory factor analysis (CFA) is a type of factor analysis employed to determine whether construct measures are in line with a researcher’s knowledge of the nature of the construct (or factor) (Kline, 2010). CFA’s goal is to determine whether the results conform to the proposed measurement model. This model’s foundations lie in theory and/or earlier analytical studies (‘Handbook of Disease Burdens and Quality of Life Measures’, 2010). CFA is already ingrained in the Jamovi software as and when the SEM is performed (Rosseel, 2012).

The SEM was employed following the TPB model to investigate the logical connections between the citizens’ cognitions (attitudes, subjective norms, and perceived behavioural controls) and their intentions to use HSS. A series of multiple regressions determined causal connections between the latent constructs. Equations (3) through (5) were used to estimate all of the standardized coefficients identified in Figure 6. While performing SEM in the Jamovi 2.2.5 software, the latent variables were represented in circles (Figure 6). The triangles

represent the error terms while the double-headed arrows measure the correlation among the latent variables.

It should be noted that no value of double-headed arrows should be larger than 1. Single-headed arrows in the model represent causations or cause-effect relationships. As mentioned above, and as seen in Figure 6, there are 4 models or 4 CFAs. Here, AT, PBC, SN, and IN are exogenous variables. AT1, AT2...IN3 are indicators represented by triangles. The data type while performing SEM is chosen to be continuous because the data, by its nature, falls in a constant sequence. In the “model” option, while setting the parameters in the software, the estimation is kept automatic because Jamovi can decide if the data is normally distributed or not (Epskamp et al., 2022; Rosseel, 2012; *Useful Tools for Structural Equation Modeling [R Package semTools Version 0.5-6]*, 2022). It automatically fits the parameters using the maximum likelihood method of estimation. In SEM analysis, one of the coefficients of the indicators is to be set as a unit value for its comparison with the other coefficients. The software has already chosen the first items (AT1, SN1, PBC1, and IN1) of every latent to be 1. The detailed parameters and results can be accessed in Appendix E. The steps followed in the Jamovi software to generate SEM results have been shown in Appendix J.2.

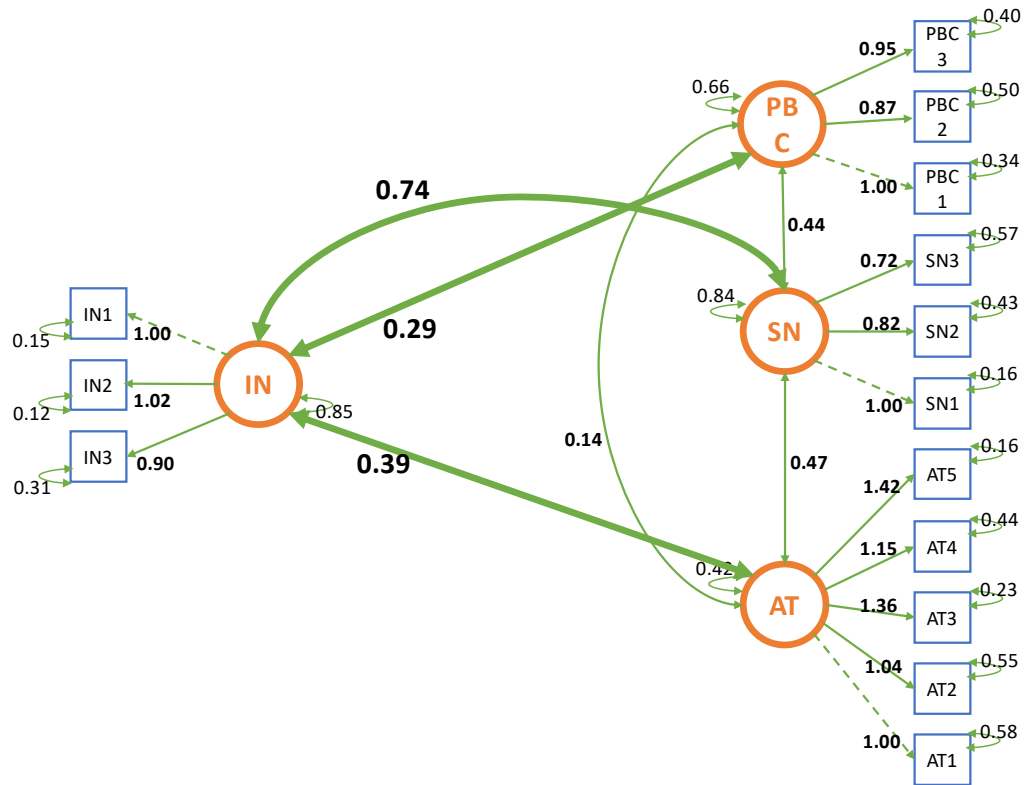


Figure 6: Standardized factor loadings and path coefficients of the final structural model based on the TPB, redrawn for better clarity (the actual figure generated by the Jamovi software can be accessed in Appendix E). Triangles represent error terms, squares represent measured items, circles represent latent constructs, straight arrows represent dependence relations and curved arrows represent correlational relations. Dotted arrows indicate insignificant effects, or the default values of latent variables (unit value). Abbreviations used are as follows: IN for intention, AT for attitude, SN for social norms, and PBC for perceived behavioural controls.

If the established SEM does not accurately reflect the data situation, as measured by goodness-of-fit, the results are unreliable. As a result, a key step in evaluating the SEM results should be model evaluation using the goodness-of-fit indices (Kang & Ahn, 2021). In this study, the final model's goodness-of-fit indices (Hair et al., 2013), as calculated by the software, were as follows: the chi-square (χ^2) test value was 138, df (degree of freedom) was 67, and the p-value was <0.001. Scholars recommend using the chi-square divided by the degrees of freedom

(χ^2/df) as a measure of model fit, with values of 5 or less being a benchmark (Hu & Bentler, 1999; Reichardt & Lomax, 2005). Here, in this research, χ^2/df came out to be 2.06, which is an acceptable model fit. One of the many incremental fit indices frequently used in linear mean and covariance structure modelling in exploratory factor analysis is the Tucker-Lewis index (TLI) (Tucker & Lewis, 1973), also known as the non-normed fit index (Bentler & Bonett, 1980). Our model's TLI value was 0.982. Therefore, the suggested TLI value should be greater than 0.90 (Bentler & Bonett, 1980; Cai et al., 2023). The absolute fit index root mean square error of approximation (RMSEA) measures how far a proposed model deviates from the ideal model (Steiger, 1990). It should lie between the lower and the upper RMSEA values, generally mentioned by the CFA/ SEM software along with the RMSEA value of the model. In the current model being studied, the RMSEA value was 0.122, which lay between the lower and the upper RMSEA values, which were 0.093 and 0.151, respectively.

Additionally, our model's comparative fit index (CFI) was 0.987, the preferable value of which should be greater than 0.9 (Xia & Yang, 2019). The CFI accounts for the sample size difficulties inherent in the chi-squared test of model fit and the normed fit index when analysing the model fit by considering the difference between the data and the hypothesized model (Bentler & Bonett, 1980). These results showed that the TPB model had strong construct and convergent validity and fit the empirical data well, suggesting that it could be utilized to evaluate the study hypotheses.

Table 3.4 displays the estimation outcomes. The attitudes and the perceived behavioural controls on the citizens' intentions had standardized path coefficients of 0.39 and 0.29, respectively. The positive effects of attitude and perceived behavioural control on intention imply that the residents' attitudes and perceived behavioural controls do have a favourable impact on the intentions to use HSS. Despite this, the standardized path coefficient of citizens'

subjective standards on their intents, 0.74, has the highest statistical significance. Because of this, the citizens' intentions to HSS are significantly influenced by their subjective norms.

Table 3.4: Model-implied covariances for latent variables

Path	Path coefficient	Hypothesis tested
IN <-- AT	0.39	H1
IN <-- SN	0.74	H2
IN <-- PBC	0.29	H3

4.4. Chi-square testing and Cross-table analysis

To conduct CTA, consideration of items having their standard deviation greater than one were done, and an additional CTA was performed on items having the highest and the lowest mean value. As seen from Table 3.2, three items have qualified for CTA under the criterion having $SD > 1$. These are SN1, SN2 and PBC2. Chi-square testing is conducted initially to identify significant associations between two items. Once the relationship is established, CTA is conducted to study the trend of the relationship. Table 3.5 below presents the outcomes of CTA wherein the items are considered pairwise. During the analysis, three kinds of relationships have been studied. High relevance would mean that both Item 1 and 2 under the consideration have been awarded high value on the Likert scale (≥ 4) or both items have been awarded low value on the Likert scale (≤ 2). An inverse relationship would imply that one of the two items under consideration has been awarded a high value on the Likert scale (≥ 4) and the other one has been awarded a low value on the Likert scale (≤ 2). The third category is the "no" relationship which implies that one of the items has been awarded 3 on the Likert scale and this does not influence the Likert value of the other item. The numerical values of CTA can be accessed in Appendix F. Since there are three relationships, it is expected that the value under

each category of the relationship should be around 33.33%, however, during the CTA, the relationships showing extreme trends have been discussed.

Table 3.5: Heat mapping of the CTA results (refer to Appendix F for the numerical values)

Item 1	Item 2	Colour mapping of CTA results				
PBC2	SN2	High	High	Medium	Low	Low
		Medium	High	High	High	High
		Low	Medium	High	High	High
		No relationship	Medium	High	High	High
		Inverse relationship	Medium	High	High	High

Table 3.5 shows the visual representation of the CTA results. For PBC2 and SN1, the chi-square value is 25.8 and the p-value is 0.056, which is greater than 0.05. This implies that PBC2 has no relationship with SN1. Alteration in one item's value does not influence the other item, in other words, the respondents are not much influenced by their peer groups for their trust to easily get the technical support in the HSS technology. On the other hand, for PBC2 versus SN2, the chi-square value is 41.9, and the p-value is less than 0.001, implying that there is a relationship between getting influenced by the neighbours regarding the usage of HSS. Row 2 in Table 3.5 displays the CTA for PBC2 versus the next item in the SN category, SN2 (corresponding table in Appendix F). 45.94% of respondents have shown high relevance between PBC2 and SN2 in Table F.2. However, 40.54% and 13.51% have shown no relationship and inverse relationship between the two items respectively.

For the last chi-square test between AT4 and SN2, AT4 and SN2 have the highest and the lowest average values. The chi-square value is 18, DF is 12, and the p-value is 0.117, indicating that there is no relationship between these two variables.

5. Discussion

This section is divided into two sub-sections: 1) the usefulness of TPB in forecasting Indian individuals' intentions to utilize HSS, and 2) a discussion on the community reach and getting support for HSS technology.

5.1. The usefulness of TPB in forecasting Indian individuals' intentions to utilize HSS and visibility of behaviour among the individuals

This section discusses the usefulness of TPB in forecasting Indian individuals' intentions to utilize HSS. According to the TPB, subjective norms have the highest impact on people's intentions to utilize HSS in this research. The plausible reason for that could be explained by Maslow's theory of human motivation. Maslow's theory of human motivation, published in 1943, suggests that the physiological demands at the pyramid's base should be satisfied before those at a higher level (Maslow, 1943). Higher-level requirements start to manifest once the basic needs are well met. Since the inhabitants in this poll have adequate living conditions and educational levels (72 out of 74 respondents are above the government of India's definition of "below the poverty line"), practically all of them have satisfied their basic necessities (e.g., physiological needs, safety needs). Higher-level needs like social wants (including belongingness and affection) and spiritual needs should now be the focus of attention (e.g., self-respect, self-actualization). The citizens are less focused on psychological presupposition (i.e., constrained by their thinking inertia) while making decisions because of their deliberate pursuit of social acceptability or support. As a result, social influences considerably impact citizens' decisions. Recycling behaviours are conspicuous actions that provide societal

pressure on people to engage in more recycling behaviours. Numerous research have provided empirical support for the relationship between recycling intention and the established subjective norm (Hornik et al., 1995). For instance, Cheung et al. (1999) conducted empirical research and found that subjective norm significantly influences the desire to recycle wastepaper (Cheung et al., 1999). Several authors have also produced similar findings mentioning that social norms significantly impact recycling behaviour (Chen & Tung, 2010; Comber & Thieme, 2013; Knussen & Yule, 2008; Mannetti et al., 2004).

These results demonstrate the TPB model's usefulness in forecasting Indian individuals' intentions to utilize HSS. Effective strategies should promote citizens' favourable subjective norms toward these reuse practices. People follow social conventions because they want to get the respect of important people while avoiding their judgment (Comber & Thieme, 2013; Gilbert et al., 2010; White et al., 2009). Additionally, social influence is bidirectional and can occur through various channels. For instance, the media and environmental organizations are two other avenues through which people might be influenced socially (Chan, 1998). According to the concept of the collective self, an individual would evaluate his own actions in light of the collective groupings around him (White et al., 2009). Therefore, the presence of others is a requirement for changing behavioural intentions. On the other hand, if this study were to be conducted in Africa, subjective norms would not be at their highest because that society does not have adequate living conditions.

In addition, this society has shown a trait known as visibility of behaviour, i.e., for behaviours that are publicly visible or have social consequences, subjective norms may play a more significant role in shaping intentions compared to private behaviours.

5.2. Discussion on the community reach and getting support for HSS technology

This discussion results from the CTA of PBC2 and SN2. Supportive neighbourhoods (depicted by SN2) can contribute to increased faith in government schemes and infrastructure (PBC2), which in turn can lead to better health, increased safety, and overall community pride. When people trust their neighbours and believe in their collective ability to achieve common goals, they are more likely to engage with and have faith in government initiatives (Campos et al., 2017). In addition, Peer groups and neighbourhoods can establish social norms that support engagement with government initiatives (Lisa M. Calhoun et al., 2022). When community members see their peers actively participating in and benefiting from government schemes, they are more likely to follow suit, creating a virtuous cycle of engagement and improvement. This CTA caters to objective 7 of this thesis, which is one of the minor objectives, which is to provide insights to aid policymakers in developing policies and carbon emission abatement (CEA) programs to improve sustainability, considering citizen motivations for recycling.

6. Conclusion

The result shows that the citizens understand the importance of our environment and are hopeful that a technology like HSS will reduce their carbon footprint. In addition, this study aimed to examine the influence of citizens' cognitions (attitude, subjective norm, and perceived behavioural control) on their intentions to reuse HSS in the form of hydrochar for reducing carbon emissions. As far as SEM is concerned, it is a commonly used multivariate statistical analysis technique used by scientists, economists, and academicians worldwide. In this research, where the respondents are mainly classified as having adequate living conditions in a developing nation, it is found that more focus should be paid to the subjective norms compared to the attitudes and perceived behavioural controls so that the impact on the citizens' intentions to use HSS would be the highest.

Additionally, the CTA examined the interplay between social influences and environmental technology adoption. Supportive neighbourhoods foster increased faith in government initiatives, leading to improved community well-being. A positive outlook on hydrochar's environmental benefits is noted, with highly educated neighbours potentially influencing adoption decisions. Their understanding of hydrochar's scientific principles may lead to more convincing explanations of its benefits. This creates a positive feedback loop, reinforcing beliefs in hydrochar's effectiveness and increasing adoption rates.

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Expanding the theory of planned behaviour for municipal solid waste recycling

1. Introduction

Due to population growth (Sibly & Hone, 2002; The World Bank IBRD and IDA, 2023), the massive use of pesticides and fertilizers in modern agriculture and the resulting waste production (Brata & Utama, 2020; V. Kumar & Kumar, 2019; Maroni et al., 2006), the expansion of the food processing sector (PIB Delhi, 2022; Press Trust of India, 2022; Riethmuller & Chai, 1995), and the development of other industrial processes (IBISWorld, 2023), including electronic wastes (Forti, 2020; IISD, 2021), all contribute to the high volumes of municipal solid wastes (MSW). In dense metropolitan areas, effective waste management systems preserve community health (Nwachukwu et al., 2013; Sachs et al., 2021; US EPA, 2023a). Nevertheless, garbage disposal is expensive (Balkan Green Energy News, 2022; Durand et al., 2018; Huber Technology, 2023), and MSW is frequently disposed of untreated (US EPA, 2023b). Consequently, this spreads bacteria, worms, and potentially hazardous waste chemicals, engendering health-related problems, including asthma, hepatitis, cholera, and even cancer (Alam & Ahmade, 2013; Alfred Chengula et al., 2015). Given that the recycling intention of MSW is low worldwide (Burneo et al., 2020; Valenzuela-Levi et al., 2021), this conflicts with our results in the previous chapter, which says that it is easier to influence people to use HSS. A way to reduce MSW is to convert the MSW to hydrochar through hydrothermal carbonisation (HTC). Does the visibility of behaviours also affect MSW recycling? This sets the stage for the subsequent exploration of MSW management, and compares it with the management of SS, to check if TPB can also be applied to increase adoption of hydrochar made

from MSW. The discourse shifts towards the broader environmental implications arising from population growth, agricultural practices, and industrial developments. The lens widens to encompass the potential of hydrothermal carbonisation (HTC) as a transformative solution for MSW, offering a promising avenue for energy generation, environmental remediation, and sustainable resource utilization.

Widespread adoption of HTC is recorded owing to its direct and indirect roles in, inter alia, pathogen removal, soil remediation, energy production and storage, co-composting, heavy metals removal, organic pollutants and phosphates removal from wastewater, and greenhouse gas emissions reduction (Padhye et al., 2022a; Sharma et al., 2021). MSW can be transformed into a source of energy from which local economies can generate income (Kempegowda et al., 2017; Padhye et al., 2022b).

For sustainable development, governments worldwide must change their municipality growth pattern from the conventional extensive mode to a low-carbon economic one (Dou, 2014; Haines & Dora, 2012). This is true from both national and international viewpoints (Ionescu, 2021; Zhang, 2010). Reusing garbage and promoting a circular economy has caught the attention of governments all over the world recently (COP 26 Media, 2021; Dwyer, 2013; Kaya & Schofield, 2020; Schmidt et al., 2013; UNFCCC, 2023). The UN emphasizes the importance of recycling waste and the pressing need to advance the circular economy to reduce pollution and address global warming (Chertow, 2009; COP 26 Media, 2021; Lusky, 1976; Sachs et al., 2021; UNFCCC, 2023). Further, the impact of numerous socio-economic characteristics, such as citizens' educational levels and salaries, has received considerable attention in most studies on citizens' reuse decisions concerning recycling (Burneo et al., 2020; Huang et al., 2020; Shehrawat et al., 2015). However, these socioeconomic factors fail to account for the true driving forces behind individuals' choices and actions (Berger, 1997; Challcharoenwattana & Pharino, 2018; Shehrawat et al., 2015).

In this light, this chapter attempts to determine the influence of citizens' cognitions in the municipal area of Jaipur, considering the same subjects as in Chapter 3, on their intentions to use HMSW from a socio-psychological perspective. The linkages in the TPB model are simultaneously estimated using structural equation modelling (SEM) to ascertain the relative importance of these three constructs. The study aims to have an in-depth discussion on reasons for human behaviour. The findings of this study will be then compared with the findings of chapter 3, wherein the intention was tested for HSS.

2. Research flow

Similar to Chapter 3, this study starts with the data collection from the quantitative survey, and the raw data is compiled after that, as shown in Figure 7. The respondents are the same people who participated in the questionnaire related to the HSS. Simultaneously, two tests are conducted to examine the data: the Shapiro-Wilk test to assess normal distribution and the Cronbach's α test to measure consistency and reliability. If the Shapiro-Wilk test fails (W not close to 1), the data is far from normal distribution and cannot be used for SEM. If Cronbach's α test fails (Cronbach's α value < 0.60), it implies that the data is not reliable and consistent, and additional qualitative surveys are recommended to be conducted to obtain more data. When both tests are cleared, the study can proceed with SEM using TBP, and also perform CTA additionally after passing the chi-square test thereafter to understand the relationship between different variables.

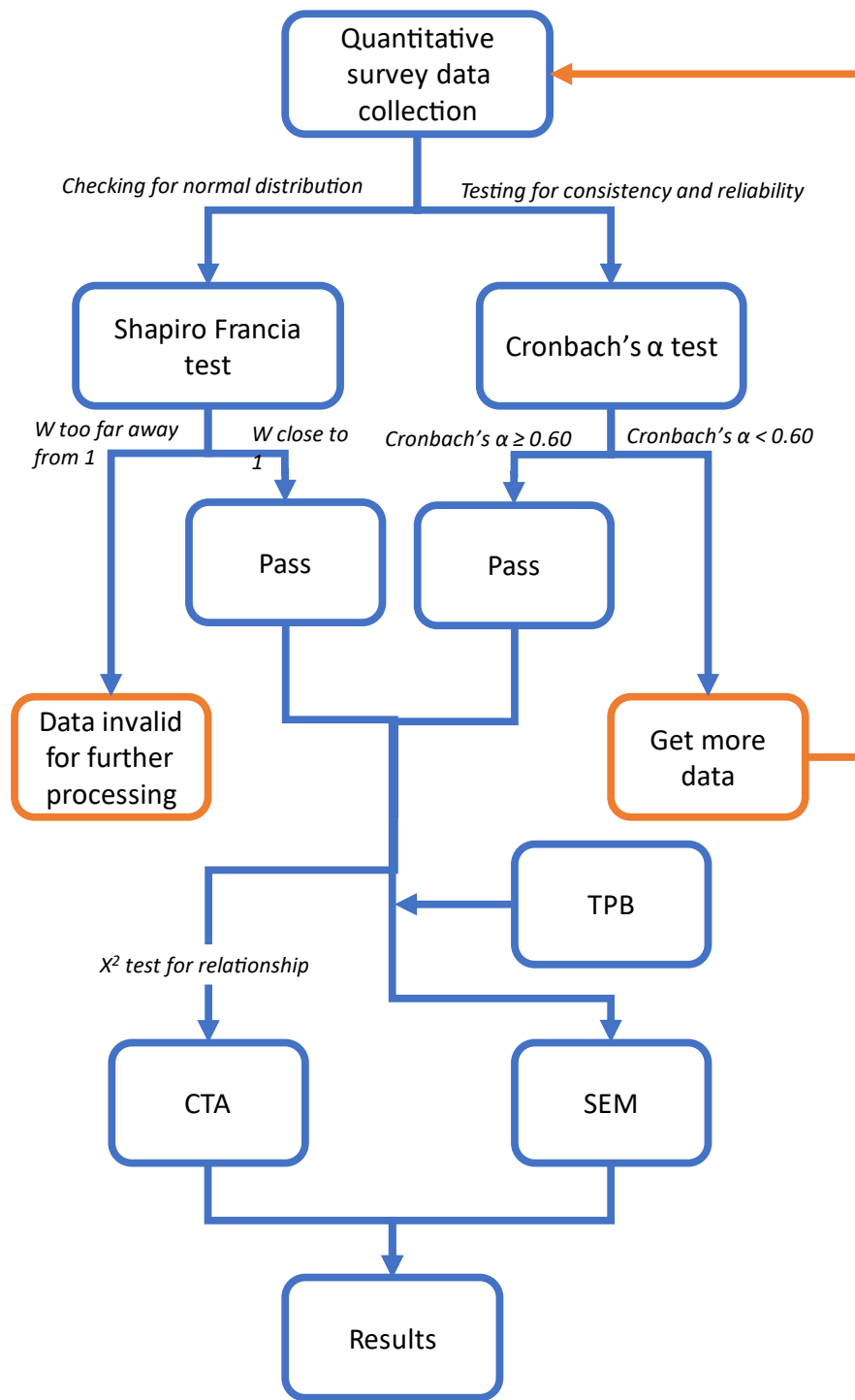


Figure 7: Flowchart depicting research flow. Abbreviations used in this flowchart are as follows: TPB for the theory of planned behaviour, CTA for cross-table analysis and SEM for structural equation modelling.

3. Research methodology and data collection

The following section commences with the process of sampling and data collection. It then delves into the demographic features of the sample and verifies the consistency and validity of the data through the application of Cronbach's α and the Shapiro-Wilk tests, ensuring that the data is fit for further modelling. The Theory of Planned Behaviour (TPB) is then introduced alongside three hypotheses, followed by a discussion on the concept of Structural Equation Modelling (SEM), similar to the methodology used in Chapter 3, having the same respondents, followed by the cross-table analyses of the items having standard deviation greater than 1.

3.1. Sampling and data collection

The data for this study was obtained via online and a face-to-face questionnaire with the same respondents in Jaipur, India. The study was stopped at 74 responses as soon as responses passed the validity and reliability test (section 3.3). The last part of the survey utilized a five-point Likert scale where participants could choose from responses ranging from "1=strongly disagree" to "5=strongly agree." Additionally, the survey included five questions related to attitudes, three focused on subjective norms, and three on perceived behavioural controls and HMSW intentions. To view the survey sheet, please refer to Appendix G.1 for the English version and Appendix G.2 for the Hindi version.

3.2. Demographic characteristics of the sample

The study surveyed a total of 74 individuals, with 47 identifying as male and 27 as female. The age range of participants spanned from 19 to 64, with an average age of 28.29 years. It is worth noting that the mean age is comparable to the median age recorded in the 2020 Indian census, which was 28.4 years (Worldometer, 2022). As such, the sample can be considered both typical and representative for this investigation.

3.3. Consistency and the validity of the dataset

For optimal results, it is crucial to ensure that the survey data is both consistent and reliable. To measure the internal consistency of a set of items, Cronbach's α values are employed. This is a widely recognized indicator of scale dependability, and further information on the formula can be found in section 3.3 of Chapter 3.

In the context of SEM, it is assumed that the data being analysed follows a normal distribution (Donaldson, 1999; S. Kumar & Upadhaya, 2017). To determine whether a population is normally distributed, a statistical test based on sample data is used, known as the Shapiro-Wilk test (Shapiro & Wilk, 1965). This test has been discussed in detail in section 3.3 of Chapter 3.

3.4. Theory of Planned behaviour

Theory of Planned Behaviour (TPB), a socio-psychological framework, explained in detail in the previous chapter aimed to decipher citizens' intentions regarding the use of MSW-derived hydrochar (HMSW). The TPB illuminated the psychological determinants influencing human behaviour, laying the foundation for an in-depth discourse on the motivations driving recycling efforts

3.5. Chi-square test and Cross-table analysis, *Introduction of*

Cross-table analysis (CTA), after passing the Chi-square test, is incorporated to unravel the intricate relationships among various variables, providing valuable insights into the multifaceted factors influencing human behaviour within the waste management paradigm.

4. Results

This part covers the claims and statistical data related to the measured factors such as attitude, subjective norm, perceived behavioural control, and intention. After conducting consistency

and validity tests on the gathered data, this section proceeds to SEM, which involves confirmatory factor analysis and determining the relationships and paths between the measured factors, followed by the CTA. Finally, it compares the results of CFA presented in this chapter with those of Chapter 3.

4.1. Item measurements

Three questions each for subjective norms, perceived behavioural controls, and HMSW intentions were created, and five questions for attitude assessment. Table 4.1 displays the specific statements and descriptive data for the measured items.

Table 4.1: Measured items’ assertions and descriptive statistics, representing attitude, subjective norm, perceived behavioural control, and intention.

Construct	Item	Statement	Mean	Standard deviation
Attitude (AT) (Fielding et al., 2008; Jiang et al., 2018)	AT1	HMSW can increase my economic income.	3.89	0.84
	AT2	HMSW production will alleviate air pollution in rural and urban areas.	3.78	1.02
	AT3	I support the acceptance of HMSW contributing to human health.	4.12	0.70
	AT4	The utilization technologies of hydrothermal carbonization/ hydrochar are environmentally friendly.	4.12	0.83
	AT5	HMSW is necessary to make our environment sustainable.	3.96	0.88
Subjective Norm (SN) (Fielding et al., 2008; Jiang et al., 2018)	SN1	My peer group will think positively of me when they get to know that I am using HMSW products.	3.74	1.01
	SN2	Highly educated neighbours’ opinion has a great influence on my decision about hydrochar.	3.28	1.20
	SN3	Wealthy and influential leaders would approve of the behaviours of HMSW use.	3.73	1.02
Perceived Behavioral	PBC 1	I have enough money to adopt the technologies of hydrothermal carbonization/ hydrochar products.	3.54	0.88

Control (PBC) (Jiang et al., 2018; Oliver & Rosen, 2010)	PBC 2	I can easily get technical support in HMSW from industrial technical experts if and whenever I want.	3.20	1.12
	PBC 3	I am confident that I can quickly learn and master the technologies of the usage of HMSW.	3.99	0.77
Intention (IN) (Folse et al., 2010; Jiang et al., 2018)	IN1	I intend to learn the utilization technologies of MSW.	4.11	0.82
	IN2	I am willing to reuse MSW to protect the environment and to be in harmony with nature.	4.20	0.88
	IN3	I would like to reuse MSW to conform to the future development trend of low carbon emissions.	4.16	0.88

The individuals surveyed had an overall positive view of utilizing HMSW, as evidenced by the data in Table 4.1. The mean scores for the five attitudes ranged from 3.78 to 4.12, with a reference value of 2.5 on the Likert scale of 1 to 5. Furthermore, the respondents indicated high levels of perceived behavioural control and somewhat high subjective norms when using HMSW. The average range for all items measuring these factors is 3.20 to 3.99, with the highest mean value of 4.20 found in item IN2 (Table 4.1), where the respondents expressed a willingness to reuse MSW for the sake of environmental protection and harmony with nature. This indicates that the citizens recognize the importance of our environment and are motivated to reduce their carbon footprint. The item with the lowest standard deviation (0.70) is AT3, in which the respondents expressed a willingness to support the acceptance of HMSW as a means of contributing to human health. The three items used to measure intent received the lowest mean score of 4.11, but the respondents still expressed a positive intention to use HMSW.

4.2. Consistency and Validity test

The consistency and validity of the formal survey data have been analysed first. This was achieved by conducting the Cronbach's α test to assess the reliability and validity of the data.

The results indicated a high level of internal consistency, with the combined Cronbach's α value for citizens' attitudes, subjective norms, and perceived behavioural controls being 0.81. Additionally, the Cronbach's α value for all observed items under the intention to use HMSW was 0.87, further confirming good internal consistency.

To determine the normal distribution of each item, the Shapiro-Wilk test was utilized through Jamovi software, with a significant threshold of 0.05 for each case's α value. As demonstrated in Table 4.2, the corresponding Shapiro-Wilk W value is close to 1, indicating that the data adheres to a normal distribution.

Table 4.2: Shapiro-Wilk W-value of each item set (α kept as 0.05)

Item	W value
AT1	0.882
AT2	0.796
AT3	0.811
AT4	0.827
AT5	0.809
SN1	0.878
SN2	0.900
SN3	0.882
PBC1	0.867
PBC2	0.897
PBC3	0.840
IN1	0.772
IN2	0.731
IN3	0.768

4.3. Structural Equation Modelling

Utilizing the TPB model, the SEM was implemented to study the interrelations between citizens' attitudes, subjective norms, and perceived behavioural controls with their intentions

to use HMSW. Through a sequence of multiple regressions, the causal connections between the latent constructs were determined. During the execution of SEM in the Jamovi 2.2.5 software, the latent variables were depicted as circles (Figure 8). The triangles signify the error terms, while the double-headed arrows gauge the correlation among the latent variables.

The value of double-headed arrows should not exceed 1. In the model, single-headed arrows indicate causation or cause-effect relationships. As depicted in Figure 8, there are 4 CFAs in total, including exogenous variables AT, PBC, SN, and IN. The indicators, represented by triangles, are denoted as AT1, AT2...IN3. Continuous data types are preferred in SEM analysis due to their sequential nature. During the analysis, one of the indicator coefficients needs to be set as a unit value for comparison purposes with the other coefficients. The software has already chosen the initial items (AT1, SN1, PBC1, and IN1) of each latent to be 1. The actual mode and calculations by the software can be accessed in Appendix H.

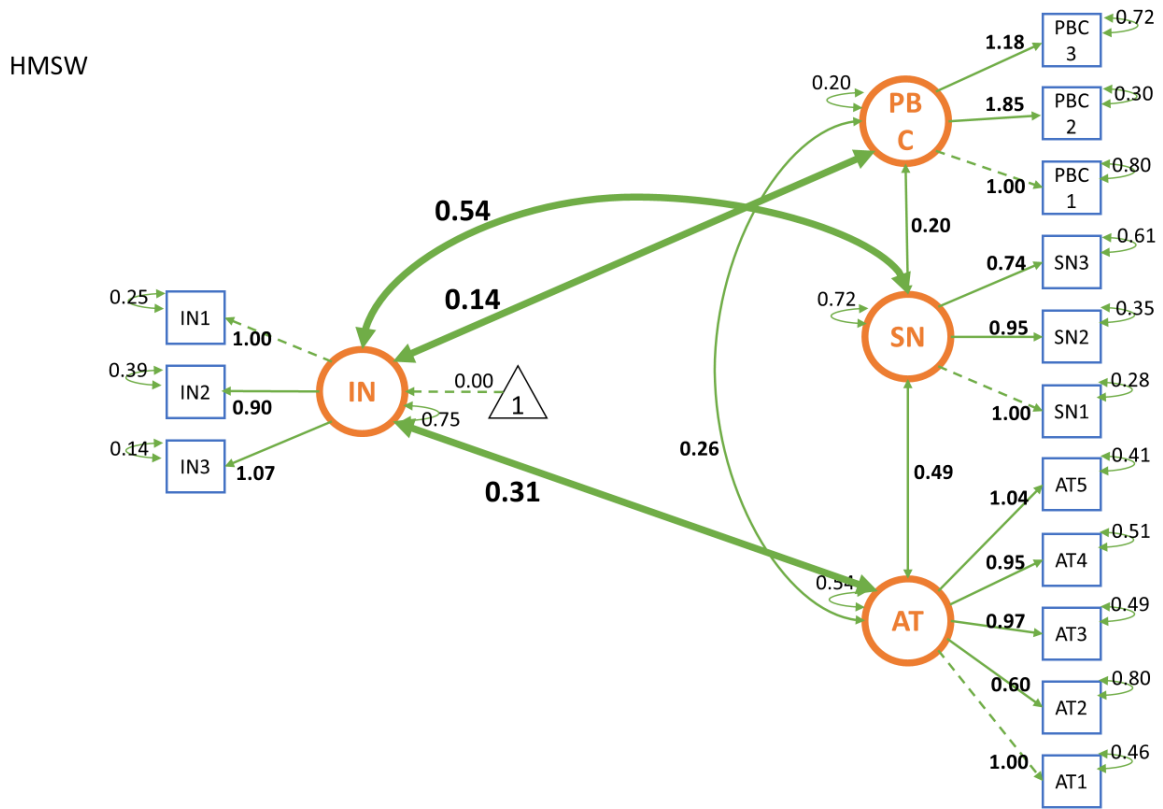


Figure 8: Standardized factor loadings and path coefficients of the final structural model based on the TPB, redrawn for better clarity (the actual figure generated by the Jamovi software can be accessed in Appendix G). Triangles represent error terms, squares represent measured items, circles represent latent constructs, straight arrows represent dependence relations and curved arrows represent correlational relations. Dotted arrows indicate insignificant effects, or the default values of latent variables (unit value). Abbreviations used are as follows: IN for intention, AT for attitude, SN for social norms, and PBC for perceived behavioural controls.

If the SEM in use does not accurately represent the data situation, as measured by the goodness-of-fit, then the results produced by the model are unreliable (Hair et al., 2013). Therefore, it is crucial to evaluate the model's goodness-of-fit indices (Kang & Ahn, 2021) when analysing SEM results. In this research, the goodness-of-fit indices of the final model, calculated by the software, were as follows: the chi-square (χ^2) test value was 88.1, the degree of freedom (df) was 71, and the p-value was 0.082. To measure model fit, scholars recommend using the chi-square divided by the degrees of freedom (χ^2/df), where a value of 5 or less is considered a benchmark (Hu & Bentler, 1999; Reichardt & Lomax, 2005). In this study, χ^2/df was 1.24, indicating an acceptable model fit. One of the many incremental fit indices used in exploratory factor analysis for linear mean and covariance structure modelling is the Tucker-Lewis index (TLI) (Tucker & Lewis, 1973), also known as the non-normed fit index (Bentler & Bonett, 1980). The TLI value of our model was 0.989. A suggested TLI value should be greater than 0.90 (Bentler & Bonett, 1980; Cai et al., 2023). The root mean square error of approximation (RMSEA) is an absolute fit index that measures how far a proposed model deviates from the ideal model (Steiger, 1990). The CFA/SEM software typically provides the lower and upper RMSEA values along with the RMSEA value of the model. In this study, the RMSEA value was 0.057, which falls between the lower and upper RMSEA values of 0.00 and 0.093, respectively.

The value of our model's comparative fit index (CFI) was 0.991, which is preferred to be greater than 0.9. CFI takes into account the difficulties associated with sample size in the chi-squared test of model fit and the normed fit index when analysing model fit, by measuring the difference between the data and the hypothesized model. These results indicate that the TPB model has strong construct and convergent validity and fits the empirical data well. Therefore, it could be used to evaluate the study hypotheses.

The estimation outcomes are presented in Table 4.3. The standardized path coefficients of attitudes and perceived behavioural controls on citizens' intentions were 0.31 and 0.14, respectively. This suggests that citizens' attitudes and perceived behavioural controls have a favourable impact on their intentions to use HMSW. However, the standardized path coefficient of citizens' subjective standards on their intents, which is 0.54, is the most statistically significant. This indicates that citizens' subjective norms significantly influence their intentions to use HMSW.

Table 4.3: Model-implied covariances for latent variables

Path	Path coefficient	Hypothesis tested
IN <-- AT	0.31	H1
IN <-- SN	0.54	H2
IN <-- PBC	0.14	H3

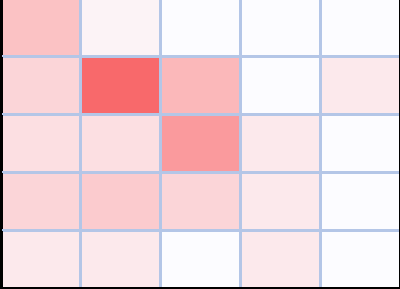
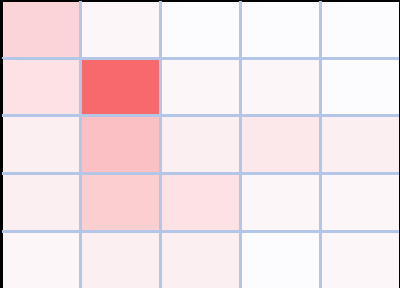
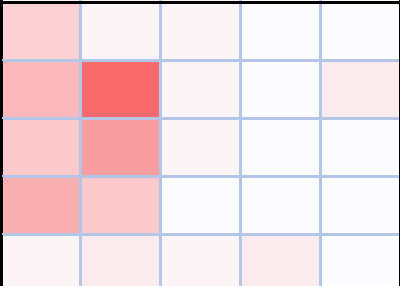
4.4. Chi-square test for independence and Cross-table analysis

To conduct CTA, consideration of items having their standard deviation greater than one were done, and an additional CTA was performed on items having the highest and the lowest mean value. As seen from Table 4.1, five items have qualified for CTA under the criterion having $SD > 1$. These are AT2, SN1, SN2, SN3 and PBC2. Chi-square test was considered for each

mutually exclusive pair to check for a relationship between the two items. If the pair passed the Chi-square test, CTA was then studied to explore the trend of the relationship. Table 4.4 below presents the outcomes of CTA wherein the items are considered pairwise. During the analysis, three kinds of relationships have been studied. High relevance would mean that both Item 1 and 2 under the consideration have been awarded high value on the Likert scale (≥ 4) or both items have been awarded low value on the Likert scale (≤ 2). An inverse relationship would imply that one of the two items under consideration has been awarded a high value on the Likert scale (≥ 4) and the other one has been awarded a low value on the Likert scale (≤ 2). The third category is the “no” relationship which implies that one of the items has been awarded 3 on the Likert scale and this does not influence the Likert value of the other item. The numerical values of CTA can be accessed in Appendix F. Since there are three relationships, it is expected that the value under each category of the relationship should be around 33.33%, however, during the CTA, the relationships showing extreme trends have been discussed.

Table 4.4: Heat mapping of the CTA results (refer to Appendix I for the numerical values)

Serial Number	Item 1	Item 2	Colour mapping of CTA results	Corresponding table in Appendix I
1	SN1	AT2		Table I.1.
5	PBC 2	SN2		Table I.2.

6	PBC 2	SN3		Table I.3.
7	PBC 2	AT2		Table I.4.
8	PBC 2	IN2		Table I.5.

For the pair AT2 and SN1, the chi-square test reveals that the chi-square value is 28.8, and the p-value is 0.026, which is less than 0.05. This indicates that there is a relationship between these two variables. To understand the relationship, Table 4.4 shows the visual representation of the CTA results. From row 1 in Table 4.4 (Table I.1 as the corresponding table in Appendix I), it is noticed that AT2 and SN1 show high relevance. 50% of people have either given a high Likert value (≥ 4) to both the items or a low Likert value (≤ 2) to both items, in other words, AT2 and SN1 have shown a high relevance to each other (Table I.1). However, 16.21% of respondents have shown an inverse relationship between the two, as in, AT2 has been valued high but SN1 has been valued low by them, or vice-versa. 33.78% of respondents have shown a neutral relationship between the two items which means that for any one of the items, AT2 and SN1, the Likert scale value is 3. Alteration in one item's value does not influence the other item.

For AT2 versus the next item in the SN category, SN2, the chi-square value comes out to be 24.2 and the p-value is 0.085 (> 0.05), implying that there is no relationship between the variables, hence not proceeding to the CTA. Similarly, for AT2 and SN3, the chi-square value comes out to be 18 and the p-value to be 0.324 which is much higher than 0.05. hence, there is no relationship between AT2 and SN3.

For SN1 and PBC2, the chi-square value is 22.1, and the p-value is 0.141, failing the test hence, there is no relationship between these two variables. For the items PBC2 and SN2, the chi-square value is 36.1 and the p-value is 0.003, meaning that there is a relationship between PBC2 and SN2. Similarly, the chi-square value is 37.3 and the p-value is 0.002, confirming the relationship between these two variables of PBC2 and SN3. 44.59% of respondents have given either ≥ 4 to both the items in row 5 of Table 4.4 or given ≤ 2 to both items. 37.83% of respondents have marked 3 to either SN2 or PBC2, and 17.56% of respondents have exhibited an inverse relationship. Though the percentage of inverse relationships is the same in row 2 (Table I.2 as the corresponding table) and 6 (Table I.3 as the corresponding table), the relevance of the items in row 2 is much higher than in row 3 in Table 2.

In row 3 of Table 4.4 (Table I.3 as the corresponding table in Appendix I), 40.54% exhibit a high relationship between the two items. Cases of no relationship and inverse relationship between the two items are 39.18% and 20.27% respectively. Notice that the highest relevance has been shown in the CTA of SN2 versus PBC2, followed by SN3 versus PBC2 and no relationship between SN1 versus PBC2. Additionally, it was found that when AT2 was analysed against the construct SN, the pattern of relevance to AT2 is SN1 having the highest relevance. On the contrary, analysis of construct SN against PBC2 exhibits SN2 having the highest relevance, followed by SN3. The plausible reasons for those would be discussed in the next section. In continuation with the CTA, Table row 4 (Corresponding Table I.4) below performs CTA between AT2 and PBC2, after passing the chi-square test with a chi-square

value of 37.8 and p-value of 0.002. 48.64% of respondents show high relevance between the two items. 33.78% and 17.56% of respondents show no relationship and inverse relationship between AT2 and PBC2, respectively. No CTA has been performed among SN1, SN2 and SN3 because they are not mutually exclusive.

An additional CTA was performed on two items having the highest and the lowest mean value as shown in Table 4.4. the chi-square value comes out to be 38.1 and the p-value to be 0.001, IN2 and PBC2 have the highest and the lowest mean value respectively. About 44.59% of respondents show high relevance between the two items in row 5 of Table 4.4 (Table I.5 as the corresponding table). However, only 28.37% show no relationship between IN2 and PBC2, and 27.02% display an inverse relationship.

4.5. Comparison of measured items’ assertions and descriptive statistics of HSS and HMSW

For both HSS and HMSW, the set of questions was the same. It is expected that the mean of the questions should be similar. A glance at the difference in the mean value could provide insight into uncommon trends, as can be seen in Table 4.5.

Table 4.5: Comparison of mean of the survey data of each item for HSS and HSMW

Item	Statement	HSS Mean	HMSW Mean	Difference
AT1	The product can increase my economic income.	3.72	3.89	-0.17
AT2	The production of hydrochar will alleviate air pollution in rural and urban areas.	4.05	3.78	0.27
AT3	I support the acceptance of hydrochar contributing to human health.	4.07	4.12	-0.05
AT4	The utilization technologies of hydrothermal carbonization/ hydrochar are environmentally friendly.	4.16	4.12	0.04

AT5	Hydrochar is necessary to make our environment sustainable.	4.09	3.96	0.13
SN1	My peer group will think positively of me when they get to know that I am using hydrochar products.	3.80	3.74	0.06
SN2	Highly educated neighbours' opinion has a great influence on my decision about hydrochar.	3.27	3.28	-0.01
SN3	Wealthy and influential leaders would approve of the behaviours of hydrochar use.	3.64	3.73	-0.09
PBC1	I have enough money to adopt the technologies of hydrothermal carbonization/ hydrochar products.	3.91	3.54	0.37
PBC2	I can easily get technical support in hydrochar from industrial technical experts if and whenever I want.	3.47	3.20	0.27
PBC3	I am confident that I can quickly learn and master the technologies of the usage of hydrochar.	3.93	3.99	-0.06
IN1	I intend to learn the utilization technologies of MSW.	3.89	4.11	-0.22
IN2	I am willing to reuse MSW to protect the environment and to be in harmony with nature.	4.04	4.20	-0.16
IN3	I would like to reuse MSW to conform to the future development trend of low carbon emissions.	4.04	4.16	-0.12

It is seen that the highest difference is in item PBC1, which states that the respondents have enough money to adopt the technologies of hydrothermal carbonization/ hydrochar products. Though for both the HSS and HMSW the mean is greater than 2.5, respondents are more positive about having money to adopt the technologies related to HSS, the plausible reasons of which are discussed in the next section.

5. Discussion

This section is divided into five sub-sections: 1) a discussion on the applicability of TPB in predicting the intentions of Indian individuals to use HMSW, 2) a discussion on the

contradictory influence of peer groups, influential leaders, and neighbours on increasing awareness towards HMSW and getting governmental support, 3) discussion on the relationship between getting support from the governmental schemes and on increasing awareness on HMSW, 4) discussion on the relationship between willingness to use HMSW and getting support from the government, 5) ease of putting money for HSS technologies, and lastly, 6) comparison of the results of the acceptance of HSS and HMSW based on TPB.

5.1. Applicability of TPB in predicting the intentions of Indian individuals to use HMSW

Based on TPB, subjective norms have the greatest influence on people's intentions to use HMSW in this study. Similar to the theory discussed in Chapter 3, a possible explanation can be given by Maslow's theory of human motivation, suggesting that physiological needs at the base of the pyramid should be met before higher-level needs (Maslow, 1943). The respondents in this survey have sufficient living conditions and educational levels, so higher-level needs such as social needs (including belongingness and affection) and spiritual needs should be the focus of attention (e.g., self-respect, self-actualization). These findings demonstrate the usefulness of the TPB model in predicting the intentions of Indian individuals to use HMSW. Effective strategies should promote favourable subjective norms among citizens towards these reuse practices. Therefore, changing behavioural intentions requires the presence of others.

5.2. Influence of peer group, influential leaders, and neighbours on increasing awareness towards HMSW and getting governmental support

This section discusses the results of row 1 to 6 in Table 4.4 (Table I.1 to I.6 as the corresponding tables in the Appendix I). The items being analysed are AT2, SN1, SN2, SN3, and PBC2. The significance of AT2 is that it tells the awareness of people towards hydrochar and people's faith in hydrochar in combating climate change. SN1 focuses on the influence of peer groups. A peer group influences people in such a way that those who have not fully formed their identity are

more susceptible to negative peer influence (Brechwald & Prinstein, 2011). However, this peer pressure can also serve to encourage prosocial behaviours as well (Brechwald & Prinstein, 2011), in the case of this study, prosocial behaviour implies the behaviour to use hydrochar. SN2 focuses on the influence of neighbours on an individual. A neighbourhood can also be a presentation of society in a way that tells how an individual is connected to society. A neighbourhood is important because it lays the foundation for better health, increased safety, and overall community pride (Shaw, 2004). In this study, it is expected that this question would demonstrate if the community would easily accept hydrochar. Also, this question might be indicative of how much inclusive an individual feels in a community. SN3 not only discusses the impact of the influence of wealthy people and the leaders but in a way represents the influence of media and Bollywood as far as India is concerned. PBC2 focusses on getting technical support from industrial and technical experts. This question indicates a general faith in the government schemes and the infrastructure provided by the government.

When CTA was done to understand the influence of the peer group (SN1), neighbours (SN2) and wealthy people (SN3) on the awareness of using HMSW (AT2), it was found that only the peer group has the highest influence on the spreading awareness of using HMSW and its benefits. This implies that people are dependent on their peer group when it comes to increasing their knowledge on a matter or getting updated on the latest pressing issues. Studies have shown that peer group is an important factor for knowledge management and in turn, for better organizational performance (Muhammed & Zaim, 2020), and even to spread awareness about medical education like HIV prevention (Kaponda et al., 2009; Norr et al., 2004) and drug abuse (Smart et al., 1976). In this study, it is noted that peer group influence can be tapped upon to share knowledge about the environmental benefits and environmentally sustainable government schemes.

When CTA was done to understand the influence of peer groups (SN1), neighbours (SN2) and wealthy people (SN3) on the faith in getting the required technical support in HMSW usage (PBC2), it was found that the neighbours have the highest influence, followed by wealthy people and leaders, and not the peer group, which is not in line with the previous observation. A neighbourhood is vital as the degree of people's well-being increases in direct proportion to the level of neighbourhood mutual support. However, when people can find solutions to their problems through formal social support (and thereby reducing their dependency on neighbours), the impact of local mutual support is diminished when a community employs full-time social workers (Yang et al., 2022). It can be inferred that since social support is not generally established in developing countries, people are still dependent upon their neighbours and society for any kind of support, here, technical support pertaining to HMSW. An analogy can also be given that in this era of digitalisation and social media, an individual is connected to his/ her peers through social media, like, Instagram, WhatsApp, etc, which play an important part in shaping one's beliefs. However, when it comes to getting first assistance, people are still dependent on their neighbours, and so the possibility of getting influenced by neighbours, or being dependent upon them cannot be totally ruled out.

This CTA caters to minor objectives 6 and 7 of this thesis, to evaluate the level of citizen engagement in recycling initiatives, with a focus on the low adoption of recycling practices and the potential of HMSW, and to provide insights to aid policymakers in developing policies and carbon emission abatement (CEA) programs to improve sustainability, considering citizen motivations for recycling MSW.

5.3. Relationship between getting support from the governmental schemes and increasing awareness of HMSW

This section discusses the results of row 7 in Table 4.4. About 48.64% of respondents who are aware of the benefits of the HMSW believe that they will get the required technical support

from the government, and people who were unsure of the significance of HMSW usage were apprehensive about getting technical support. It can be interpreted that the well-aware and educated people are hopeful of the government policies, while on the other hand, people who are unaware of their surroundings, do not want to rely on government assistance. This CTA caters to minor objectives 6 and 7 of this thesis.

5.4. Relationship between willingness to use HMSW and getting support from the government

This section discusses the outcomes of row 8 in Table 4.4 (Table I.8 as the corresponding table), wherein IN2 has been analysed with PBC2. IN2 signifies the willingness of people to play an active part in the environment. As seen from Table 4.1, this item has got the highest average of 4.20. On the other side, PBC2 has the lowest average of 3.20. About 44.59% of respondents show high relevance in Table I.8, implying that people either want to reuse MSW to be in harmony with nature and they believe they can easily get technical support in the MSW hydrothermal carbonization/ hydrochar from the industrial technical experts, or they do not want to reuse MSW and do not believe that they will get the required support. In other words, it can be predicted that people who are willing to use the hydrochar, believe that they will easily get the government help. In continuation, 41.89% of respondents are firmly hopeful to be in harmony with nature and believe that they will get the required help. As per a related Pew research, people who believe that elected officials do not care about the views of common people are more likely to be dissatisfied with the state of democracy in their nation (Connaughton et al., 2020). As far as India is concerned, 19% of those who believe elected officials do not care what people like them think are dissatisfied with democracy – compared with 38% who think elected officials do care. In that sense, 41.89% is a good sign of trust in democracy as compared with the 38% hope reported by Pew research (Connaughton et al., 2020).

Therefore, the high relevance between the two items signifies that the government schemes, when implemented properly, can set the mood of people. A study in a developed nation shows that the appropriate balance between the proper implementation of government policy goals is equally balanced by public opinion. The study also provided support for the claim that governments adjust their preferences in response to shifts in public opinion (Bellucci & Pellegata, 2017). On the other hand, the collapse of a poorly planned government scheme can give rise to uncontained rioting, falling off, and the descend of the country into anarchy and a near civil war, as happened in Albania in which some 2,000 people were killed (Jarvis, 2000). In this study, though there is hope in the government and its schemes, it is a matter of further discussion on how streamlined schemes and policies can be put up to use the faith of the people to action. This CTA, thus, answers objective 7 of this thesis.

5.5. Ease of putting money into HSS technologies

It's interesting to note that people in developing countries are more positive about adopting technologies related to HSS than those related to HMSW. One of the reasons for this could be that people in these countries are well aware of the organic nature of their poop, which can be directly applied to fields as a fertilizer (Moya et al., 2019). In rural areas, where agriculture is a significant sector, people have a tradition of using organic waste as soil amendments (Gwara et al., 2021), which makes them more willing to adopt technologies that valorise sewage sludge. This, coupled with the potential for income generation from hydrochar-derived soil amendments or fertilizers, acts as an economic incentive for adopting HSS technologies.

On the other hand, people in developed countries are more inclined to trust municipal solid waste treatment systems (Marshall & Farahbakhsh, 2013). If the same question were asked in such countries, people might be more willing to adopt HMSW technologies. The way MSW is managed in developing countries may seem inadequate to some. This perception, combined

with concerns about the safety and composition of products derived from MSW, may discourage the use of technologies that rely on such waste.

Moreover, the socio-economic factors and education levels in developing countries play a crucial role in shaping perceptions and decision-making processes. Lower levels of education and awareness about proper waste management practices, particularly in rural areas, may contribute to the willingness to adopt technologies related to sewage sludge, which is perceived as a more familiar and organic material. Therefore, education and awareness campaigns are necessary to promote sustainable waste management practices and foster trust in emerging technologies.

Extending this further, this observation provides insight into people's thinking and their level of education. It shows that people in developing countries might take sewage sludge management into their own hands, but they may not know how to manage MSW. The CTA discussed here caters to the minor objectives 6 and 7 of this thesis.

5.6. Discussion on the difference of SEM results on the acceptance of HSS and HMSW

SEM results show that the impact of SN on IN of HSS usage is 0.74, and the impact of SN on IN on HMSW usage is 0.54. Though for both the cases (HSS and HMSW) the impact of SN is the highest on IN, the reason behind the difference between the two can be reasoned as the following. The effects of sewage are readily apparent, such as foul odours, unsightly sights, and health issues. In contrast, municipal solid waste is often collected and disposed of in a different location, leading to less direct interaction and a tendency to overlook its impact. This means that the impact of sewage and its related issues are highly localized, while the effects of municipal solid waste are more far-reaching. This is why people may be more influenced by videos or other social norms means related to sewage systems.

6. Conclusion

Individuals are willing to recycle MSW as a means of promoting environmental protection and living in accordance with nature. This study also explores the influence of citizens' attitudes, subjective norms, and perceived behavioural control on their intentions to reuse MSW for reducing carbon emissions. The study finds that in a developing nation with respondents having adequate living conditions, more emphasis should be placed on subjective norms than attitudes and perceived behavioural controls to have an impact on citizens' intentions to use HMSW. Further, CTA revealed some intricacies of the human behaviour which the present research methods fail to deliver. A contradictory pattern is observed which emphasizes the fact that a peer group plays a major role in getting awareness and forming our beliefs, however, a neighbour is the first to be approached when any onsite help or assistance is required. Another CTA evaluates that those who are knowledgeable and educated are positive about government initiatives, whilst others who are clueless about their surroundings do not wish to rely on government support. Since this study addresses the UN SDGs 7, 11 and 15, as far as government programs are concerned, when done correctly, government programmes can influence people's attitudes. Although there is hope in the administration and its plans, more discussion is needed to determine how streamlined plans and policies can be implemented to put the public's faith in action.

People in developing countries are more likely to adopt technologies related to SS than those related to MSW. This is because they are familiar with the organic nature of their poop and have a tradition of using organic waste as soil amendments in agriculture. The potential for income generation from hydrochar-derived soil amendments or fertilizers is also an economic incentive for adopting HSS technologies. In contrast, residents in the developed countries tend to trust MSW treatment systems more and may be more willing to adopt technologies that rely on waste. People in developing countries, however, may view MSW management as

inadequate and have concerns about the safety and composition of products derived from waste, which can discourage the use of such technologies.

The effects of sewage being highly localised, lower levels of education and awareness may also contribute to the willingness to adopt technologies related to sewage sludge. Therefore, education and awareness campaigns are necessary to promote sustainable waste management practices and foster trust in emerging technologies. This may lead people in developing countries to take SS management into their own hands because they lack knowledge about managing MSW.

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Conclusions

Safe sanitation is a fundamental human right, yet open defecation remains a pressing issue in many parts of the world. More than 50% of the world's population lacks access to clean water and sanitation, leading to serious health and environmental consequences. Addressing these challenges requires a holistic approach integrating the provision of safe sanitation facilities, recycling practices, and efficient waste management systems. This thesis, hence, makes an effort to understand safe sanitation practices, public attitudes, and behaviours toward recycling and waste management, which is, in turn, integral to formulating effective policies and interventions. This thesis examines the Swachh Bharat Abhiyan (SBA) Impact, investigates open defecation practices, analyses public opinion and behaviour towards sanitation practices, explores societal factors in sewage reuse, and contributes well to the Sustainable Development Goals (in particular SDG 6 and 11). All these points can be taken as research objectives which this work has successfully catered to. This thesis then proposes a solution of introducing toilets that can produce hydrochar. this thesis then explores the usage of hydrothermal carbonisation (HTC) made from both sewage sludge and municipal solid waste, applies the Theory of Planned Behaviour (TPB), and implements Structural Equation Modelling (SEM) to assess citizen engagement in recycling initiatives. This thesis can have far-reaching contributions to policy development.

The below lines first discuss the major objectives and their results, and then mention the additional results. It then discusses the recommendations, future expansion of this study, limitations, and the takeaway message or the epilogue.

1. Findings at a glance

The research aims to understand why people in developing countries continue to practice open defecation despite significant investments in WASH services. The initial qualitative research, in Chapter 2, focuses **on public perceptions and attitudes toward sanitation practices in slum areas of Jaipur, India (Objective 1)**. One notable finding is that communities in these countries often exhibit a strong sense of entitlement, as reported in Nature Scientific Reports recently (Gupta et al., 2024). This sense of entitlement suggests two potential approaches: charging for WASH services or incentivizing their use. A proposed solution is to provide toilets that produce hydrochar, a valuable resource derived from sewage sludge (HSS). However, it remains unclear whether people would be willing to adopt HSS, and if so, how their adoption could be influenced. Chapter 3 then **explores the possibilities of using hydrochar derived from in-situ sewage sludge as a sustainable energy source to tap the sense of entitlement (Objective 2)**. Further investigation using the theory of planned behaviour (TPB) and structural equation modelling (SEM) indicates that social norms (SN) have a significant impact on the intention to use hydrochar. Despite this, the existing literature mentions that people's intention to recycle, including using hydrochar, is generally low (Babaei et al., 2015; Knussen & Yule, 2008). Chapter 4 tries to understand these conflicting results and **explores the possibilities of adaptation of hydrochar derived from municipal solid waste (Objective 3)**. Extending this concept of TPB to hydrochar derived from municipal solid waste (HMSW) recycling reveals that social norms have a lesser impact on intention compared to hydrochar from sewage sludge. This disparity may be attributed to the greater visibility and familiarity of sewage sludge compared to municipal solid waste.

This study has several other findings catering to the minor objectives as shown below.

Objective 4: To assess the impact of Swachh Bharat Abhiyan (SBA) on community sanitation, and to explore the persistence of open defecation in slum areas despite the successful implementation of SBA through an on-site qualitative survey.

Findings related to Objective 4 include:

1. Financial constraints were the primary reason (89%) for not having toilets, while a small percentage (6%) preferred open defecation for fresh air and open fields.
2. Open nallahs (drains) were the most common place for open defecation, followed by nearby hills, for all categories (males, females, and children).
3. Community toilets were available but not used, mainly due to poor maintenance and inconvenient locations.
4. Major issues faced during open defecation included social harassment, illness, encounters with wildlife, time constraints, and privacy concerns.
5. Lack of funds and resources was the primary problem in toilet construction, followed by distrust in government officials and contractors.
6. Awareness of the Swachh Bharat Abhiyan (SBA) was spread through various channels, including government dispensaries, schools, mobile phones, televisions, and village walls.
7. More respondents had seen SBA advertisements than those who hadn't, indicating a relatively successful awareness campaign.

Objective 5: To contribute to the understanding of factors influencing public perception and behaviour related to sanitation, aligning with the United Nations' SDG 6.2.

Findings related to Objective 5 include:

8. Lower-income individuals tend to have stronger religious beliefs, and places of worship can be effective for promoting health-related ideas.

9. Citizens exhibit a sense of entitlement, expecting services to be free or low-cost.
10. People want toilets in their households, preferably through government schemes, but are reluctant to contribute or participate in the construction process.
11. Government messaging should emphasize the right to have a toilet and encourage people to approach government offices for assistance.
12. Local materials, such as Redstone and mudbricks, were preferred for toilet construction, increasing acceptance and potentially strengthening the local economy.
13. Using local materials for construction can contribute to employment, wages, and economic growth in the area.
14. People are more likely to help in the toilet construction process when they are unaware of the costs involved.

Objective 6: To evaluate the level of citizen engagement in recycling initiatives, with a focus on the low adoption of recycling practices and the potential of SS and MSW-derived hydrochar (HSS and HMSW, respectively).

Findings related to Objective 6 include:

15. The Theory of Planned Behaviour (TPB) model was found to be useful in forecasting Indian individuals' intentions to utilize Hydrochar.
16. Supportive neighbourhoods can contribute to increased faith in government schemes and infrastructure related to HSS.
17. Social influences significantly impact citizens' decisions regarding HSS usage, as people are less constrained by psychological presuppositions
18. Social influence is bidirectional and can occur through various channels, including media and environmental organizations.

Objective 7: To provide insights to aid policymakers in developing policies and carbon emission abatement (CEA) programs to improve sustainability, considering citizen motivations for recycling MSW.

Findings related to Objective 7 include:

19. People in developing countries still depend on neighbours and society for support, including technical assistance for hydrochar.
20. While peer groups shape beliefs through social media, neighbours are still the first point of contact for immediate assistance.
21. People who are aware of hydrochar benefits are more likely to believe they will receive technical support from the government.
22. People in developing countries are more positive about adopting technologies related to HSS than those related to HMSW.
23. Familiarity with organic waste as soil amendments in rural areas makes people more willing to adopt HSS technologies.
24. People in developing countries might be more inclined to manage sewage sludge themselves but may lack knowledge about managing municipal solid waste.
25. The impact of subjective norms on intention to use HSS (0.74) is higher than for HMSW (0.54), possibly due to the more localized and apparent effects of sewage compared to municipal solid waste.
26. Socio-economic factors and education levels in developing countries influence perceptions and decision-making processes regarding waste management technologies.

2. Recommendations

During this study, the conductor came across some ways in which the PWS can be made more efficient, as mentioned below:

1. In societies where the sense of entitlement is high, it is better to either let the beneficiaries pay for it or provide incentives to use the services. Instead of providing normal toilets with no end benefits, it is better to provide toilets with an end result, here, in our case, toilets producing hydrochar in the end.
2. Mosques can be utilized to encourage hygienic practices and inform people about government programs in areas with limited technology access, as 96% of respondents practice Islam.
3. Adding value to services is proposed as a way to address the sense of entitlement, as people tend to value what they pay for.
4. The sense of entitlement can be leveraged to motivate people to demand hygiene services from the government and stakeholders.
5. Social campaigns can be used to motivate communities and citizens to take action.
6. Peer group influence can be leveraged to share knowledge about environmental benefits and sustainable government schemes.
7. There's a need for education and awareness campaigns to promote sustainable waste management practices and foster trust in emerging technologies.

3. Limitations of this study and further expansions

The limitations of this study could be addressed in future studies. Because this study included both qualitative and quantitative surveying, it is also important that the subjects understand the questions being asked, which, however, cannot be confirmed using any methodology. The

reason is that the human mind is still illogical and sometimes fails to understand the best possible option for himself/ herself (Pinker, 2021).

Future studies could also validate and confirm the current findings by repeating the analysis on a sizable and broadly representative sample. Future research might also profit from objectively assessing measurable behaviours by watching and documenting actual recycling habits. The TPB can accurately predict up to 39% and 27% of the variance in intention and conduct, respectively (Armitage & Conner, 2001). Additionally, this model confirms that the traditional TPB model may be used to describe a citizen's intent to use HMSW. However, to improve its ability to explain people's environmental behaviours, the traditional TPB model can be expanded by including moral conviction or obligation (Chen, 2016; Tan et al., 2017). Furthermore, the model's predictability on a citizen's reuse intentions and behaviours can be improved through further research. Then, the gap between the citizen's intentions and behaviours for reusing HMSW for carbon emission reduction and environmental policymaking can be further evaluated. Also, if social norms were to be relied upon to inform citizens, it should be taken care that the information sources should be credible, especially with the usage of social media like YouTube and Instagram where misinformation can spread easily.

In addition, CTA can also be extended and evaluated for a greater number of respondents. There might be an underlying pattern in the human behavioural trend which might not be reasoned in this research. Human behaviour has been a topic of interest for scientists and philosophers. The same study can be extended to further quantitative studies to describe and classify human behaviour using widely available methods like Thurstone law of comparative judgment (Thurstone, 2017), ANOVA (Tukey, 1949) and Tukey–Kramer tests (Kramer, 1956) among many others. Also, this research does not focus on how the findings in the results will be applied in policymaking. However, the results and the application of these results in policymaking open a new stream of study and research.

4. Epilogue

This study on open defecation in developing countries provides important insights into sanitation challenges and potential solutions. Financial constraints are identified as the primary barrier to toilet ownership, with 89% citing this as the main reason for not having toilets. A strong sense of entitlement among communities, expecting free or low-cost services, presents both challenges and opportunities for implementing effective sanitation solutions. This might not only hold true for the Indian community at large but can also be true for other developing nations. More similar studies are needed in this field.

The study then proposes two approaches to address this issue: charging for WASH services or incentivizing their use. One innovative solution is the introduction of toilets that produce hydrochar, a valuable resource derived from sewage sludge, or HSS. The Theory of Planned Behaviour analysis shows that social norms significantly influence the intention to use hydrochar, particularly for HSS compared to hydrochar from municipal solid waste (HMSW).

Additionally, CTA shows that peer groups, wealthy individuals/leaders, and neighbours play crucial roles in spreading awareness and providing technical support for waste management technologies. This is important because Indian society by large is known for its education and good IT skills. Instead of trusting their own educational level or perceived behavioural controls, they are still dependent on how others think of them, hence playing a part in their own decision-making. Peer group influence can also be harnessed to share knowledge about environmental benefits and sustainable government schemes.

Interestingly, in countries like India, religion and politics go hand in hand. Religious institutions can be utilized to promote hygienic practices and inform about government programs, especially in areas with limited technology access. Furthermore, targeted education and awareness campaigns can be developed to promote sustainable waste management

practices and foster trust in emerging technologies. Additionally, improving the maintenance and accessibility of community toilets is important to encourage their use.

Implementing these recommendations and considering the complex social, economic, and cultural factors influencing sanitation practices can enable developing countries to make significant progress in reducing open defecation and improving overall public health and environmental conditions. I understand the need to recognize that, despite the availability of resources for WASH services, policymakers may struggle to fully grasp the underlying reasons for the failure of public water systems, or they may lack the motivation to delve into the deeper human behavioural aspects. It's important to support studies like this research as they can ultimately empower all stakeholders to make meaningful improvements for the well-being of communities.

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Appendix A

Customer Survey in Open Defaecation Localities, Jaipur

LOTA- Understanding Target Audience

Name /नाम-

Age /उम्र-

Address /पता-

Number of members in family /परिवार में सदस्यों की संख्या-

1. Why are you not using toilet? /आप शौचालय का उपयोग क्यों नहीं कर रहे हैं?

- Prefer open-defaecation due to fresh air & open fields /ताजी हवा और खुले खेतों के कारण खुले में शौच को प्राथमिकता
- Specified in religious scriptures /धार्मिक शास्त्रों में निर्दिष्ट है
- Financial constraints /वित्तीय बाधाएं
- Any other reason specify /कोई अन्य कारण निर्दिष्ट करें-

2. Where do the male members go for defaecation? /पुरुष सदस्य शौच के लिए कहां जाते हैं?

- open barren land /खुली और बंजर भूमि
- lush green lands /हरे भरे मैदान
- nearby nallah /पास का नाला
- Others /अन्य

3. Where do the female members of the household go for defaecation? /घर की महिला सदस्य शौच के लिए कहां जाती हैं?

- open barren land /खुली और बंजर भूमि
- lush green lands /हरे भरे मैदान
- nearby nallah /पास का नाला

- Others /अन्य

4. Where do the kids of the household go for defaecation? /घर के बच्चे शौच के लिए कहाँ जाते हैं?

- open barren land /खुली और बंजर भूमि
- lush green lands /हरे भरे मैदान
- nearby nallah /पास का नाला
- Others /अन्य

5. Do you face any problems due to not having a toilet facility? What are they? /शौचालय की सुविधा नहीं होने के कारण क्या आपको कोई समस्या है? वे क्या हैं?

- Any shameful incident with females of the house (harassment faced due to going in dark hours) /घर की महिलाओं के साथ कोई शर्मनाक घटना (अंधेरे घंटों में जाने के कारण उत्पीड़न)
- Time crunch & need to wake up too early /समय की कमी और बहुत जल्दी जागने की जरूरत है
- Illness related to bladder or stomach /मूत्राशय या पेट से संबंधित बीमारी
- Any accidents (snake, insects etc) /कोई भी दुर्घटनाएं (सांप, कीड़े आदि)
- Any other problem, specify /कोई अन्य समस्या, निर्दिष्ट करें-

6. Do you think having a toilet can significantly improve above mentioned problems? If no, then how? /क्या आपको लगता है कि एक शौचालय होने से उपर्युक्त समस्याओं में काफी सुधार हो सकता है? यदि नहीं, तो कैसे?

- Yes/ हाँ
- If No, why? /यदि नहीं, तो क्यों?

7. Do you intend to pay more expenditure of money than the government's aid for the construction of toilets if it exceeds the subsidy? /क्या आप शौचालय के निर्माण के लिए सरकार की सहायता से अधिक धनराशि का भुगतान खर्च करने का इरादा रखते हैं यदि यह सब्सिडी से अधिक है?

- Yes/ हाँ
- No /नहीं

8. In case there is no money from the government would you still construct a toilet on your own expense? /यदि सरकार के पास कोई पैसा नहीं है तो क्या आप अभी भी अपने खर्च पर शौचालय का निर्माण करेंगे?

•Yes/ हाँ

•No /नहीं

9. According to you, how much money does it cost to construct a toilet? /आपके अनुसार, शौचालय बनाने में कितना पैसा लगता है?

- 0-10,000
- 10,000- 20,000
- 20,000- 30,000
- 30,000- 40,000
- 40,000- 50,000
- Don't know /पता नहीं

10. What problems do you incur with/while constructing a toilet? /शौचालय का निर्माण करते समय आप किन समस्याओं से जूझते हैं?

- It takes a lot of time to supervise & construct /इसकी देखरेख और निर्माण में बहुत समय लगता है
- Quality of construction not as promised /निर्माण की गुणवत्ता के अनुसार वादा नहीं किया जाता है
- Needs regular maintenance & services /नियमित रखरखाव और सेवाओं की आवश्यकता है
- Contractor fills his own pocket /ठेकेदार अपनी जेब भरता है
- Lack of funds and resources /धन और संसाधनों की कमी
- No idea /पता नहीं

11. How much money are you happily willing to pay for a good toilet facility in your house? /आप अपने घर में शौचालय की अच्छी सुविधा के लिए कितने पैसे देने को तैयार हैं?

- 0- 5,000
- 5,000-10,000
- 10,000-15,000
- 15,000-20,000
- 20,000-25,000
- nil/ शून्य

12. What do you think of toilets which are low in cost and fast to construct? /क्या आप शौचालय के बारे में सोचते हैं जो लागत में कम होगा और जिसमें तेजी से निर्माण होगा?

- It must be bad/faulty as such low cost is not possible /यह खराब / दोषपूर्ण होना चाहिए क्योंकि इतनी कम लागत संभव नहीं है
- Works best for us if someone can provide facility in less price/ यह हमारे लिए सबसे अच्छा होगा अगर कोई कम कीमत में सुविधा प्रदान कर सकता है

13. Would you be interested in constructing a fast (in some hours) and easy to install toilet for your family? /क्या आप अपने परिवार के लिए एक तेज (कुछ घंटों में) और आसानी से स्थापित शौचालय का निर्माण करने में रुचि रखते हैं?

- We do not want to get involved in construction process /हम निर्माण प्रक्रिया में शामिल नहीं होना चाहते हैं
- Sounds like fun and exciting /मजेदार और रोमांचक लगता है

14. What material do you think toilets should be made of? /आपको क्या लगता है कि शौचालय किस सामग्री से बना होना चाहिए?

- Local material used in construction like stone walls etc (suggest some) /इस क्षेत्र निर्माण में प्रयुक्त स्थानीय उपलब्ध सामग्री जैसे पत्थर की दीवारें आदि (कुछ सुझाव)
- Metal Sheets like steel and GI /स्टील और जीआई जैसी मेटल शीट्स
- Strong durable Plastic /मजबूत टिकाऊ प्लास्टिक
- Mud bricks / मिट्टी की ईंट
- Wood / लकड़ी

15. Where do you see advertisements for toilets? /आप शौचालय के विज्ञापन कहां देखते हैं?

- Government Dispensaries/Hospitals /सरकारी औषधालय / अस्पताल
- Television/Mobile phones /टेलीविजन / मोबाइल फोन
- Village walls /गाँव की दीवारें
- Schools /विद्यालय
- Never heard of one / कभी किसी के बारे में नहीं सुना

16. What are your perceptions regarding using manure from the toilet? /शौचालय से प्राप्त खाद का उपयोग करने के बारे में आपकी क्या धारणाएं हैं?

- I am willing to use / मैं उपयोग करने के लिए तैयार हूँ

- I am not willing to use /मैं उपयोग करने के लिए तैयार नहीं हूँ
- I am willing to use but only for growing non- human consumption crops /मैं उपयोग करने के लिए तैयार हूँ लेकिन केवल गैर-मानव उपभोग वाली फसलों को उगाने के लिए

Appendix B

Figures used in Section 3 of Chapter 2

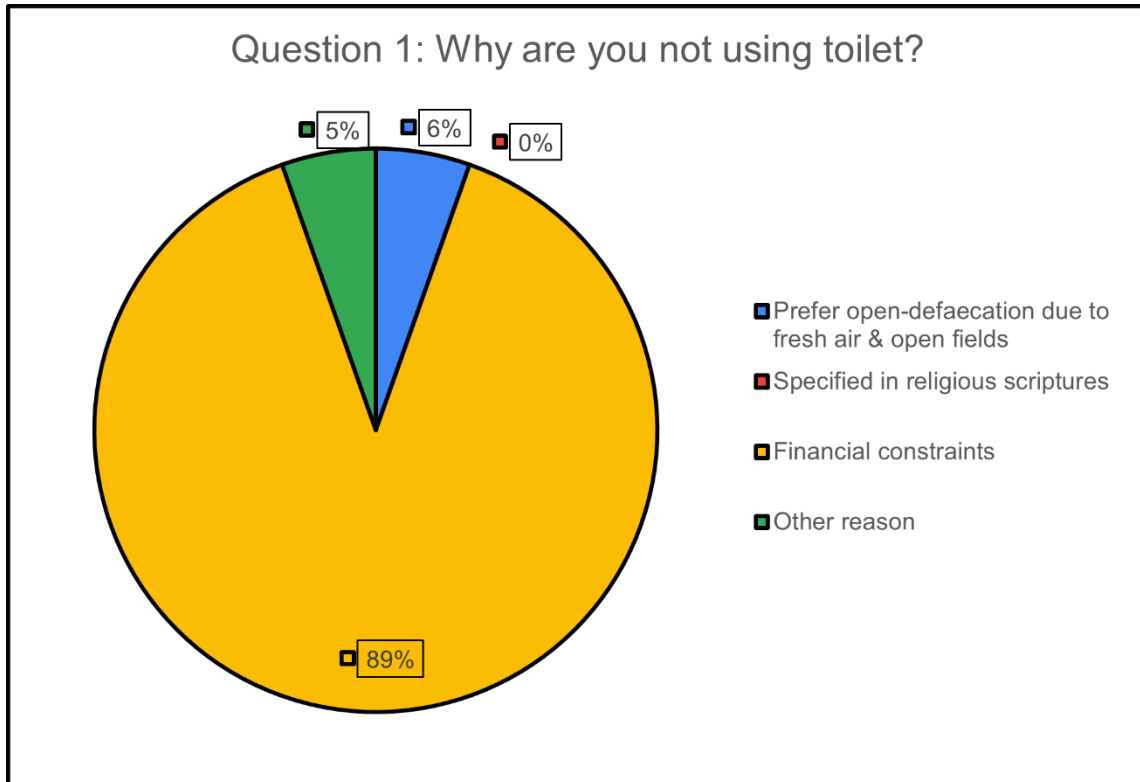


Figure B.1. Responses to Question 1 in Appendix A

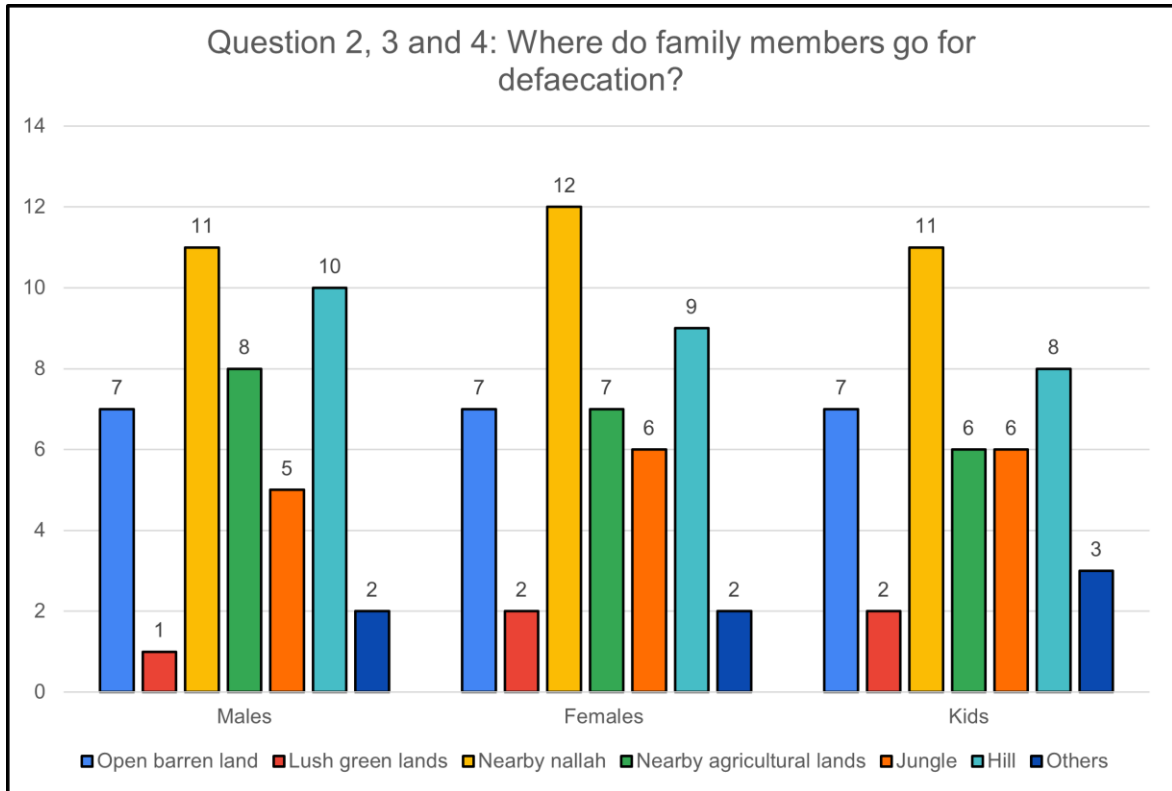


Figure B.2. Comparison of the responses to Questions 2, 3 and 4 in Appendix A

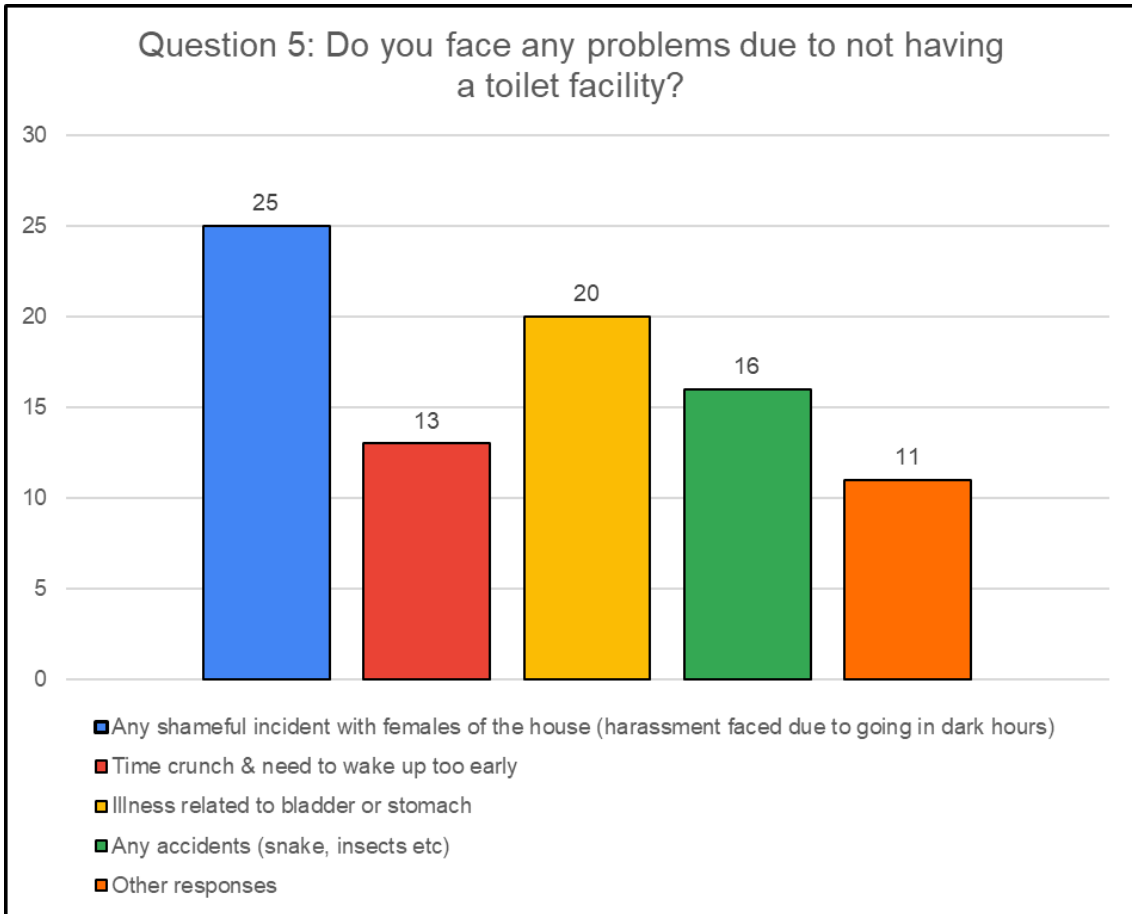


Figure B.3. Issues faced while opting for open defaecation as per Question 5 in Appendix A

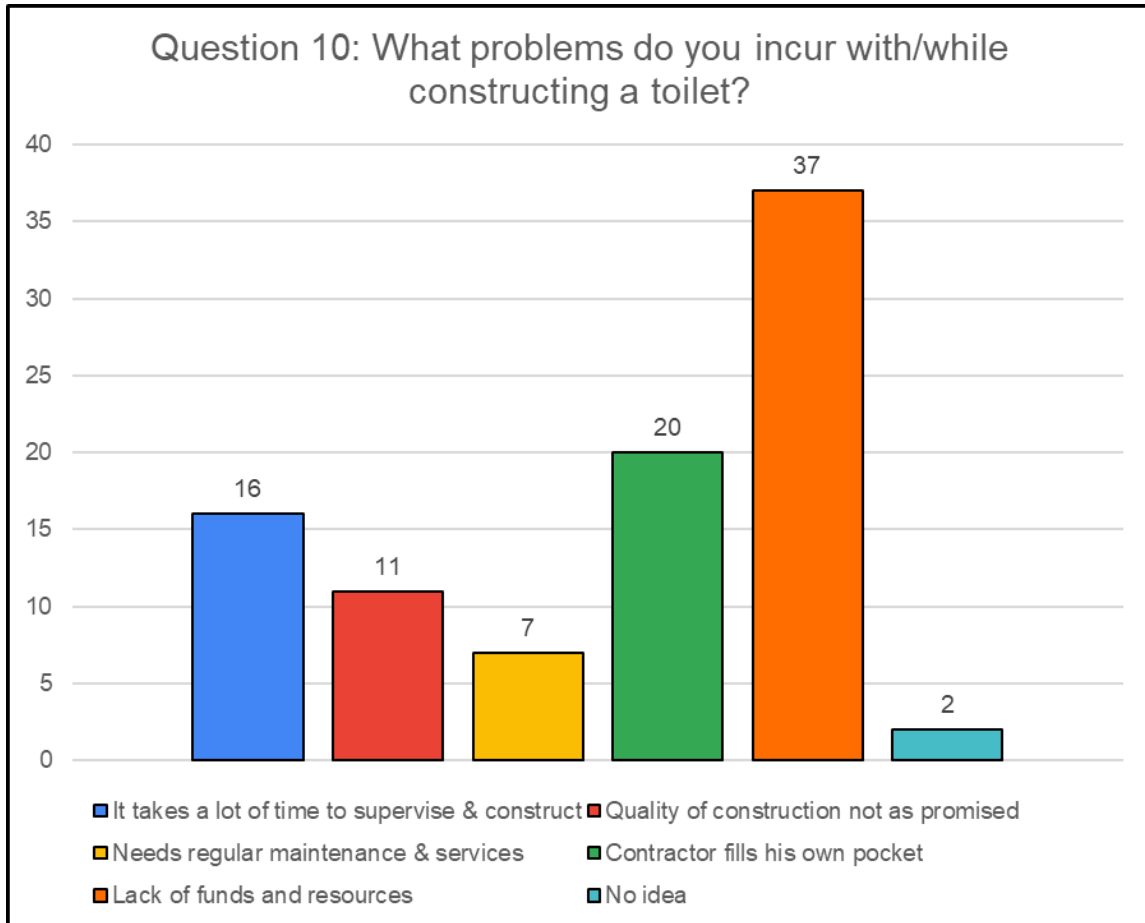


Figure B.4. Responses to Question 10 in Appendix 1

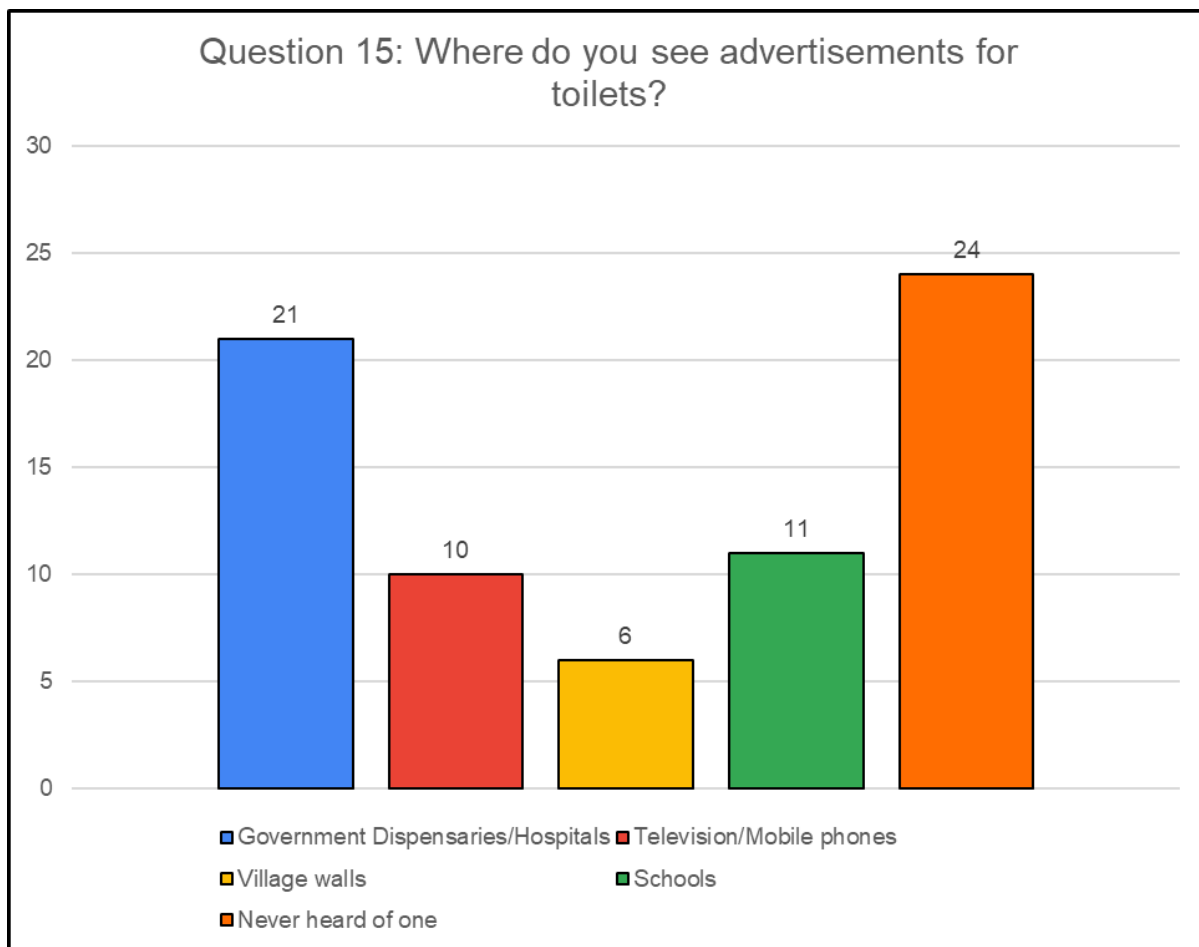


Figure B.5. Places where the toilet promotion advertisements are seen as a response to Question 15 in Appendix 1

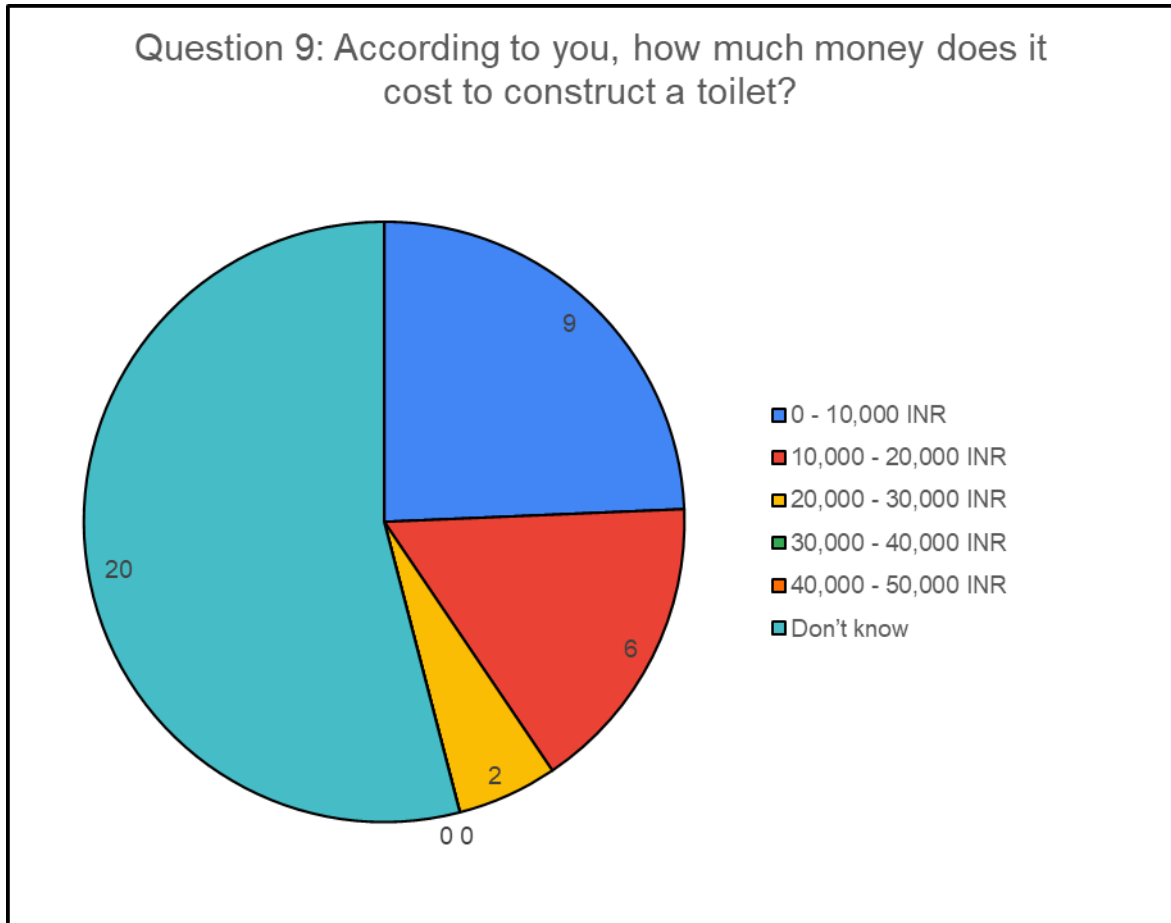


Figure B.6. Response to Question 9 in Appendix A, finding about the awareness of people regarding the cost of a toilet

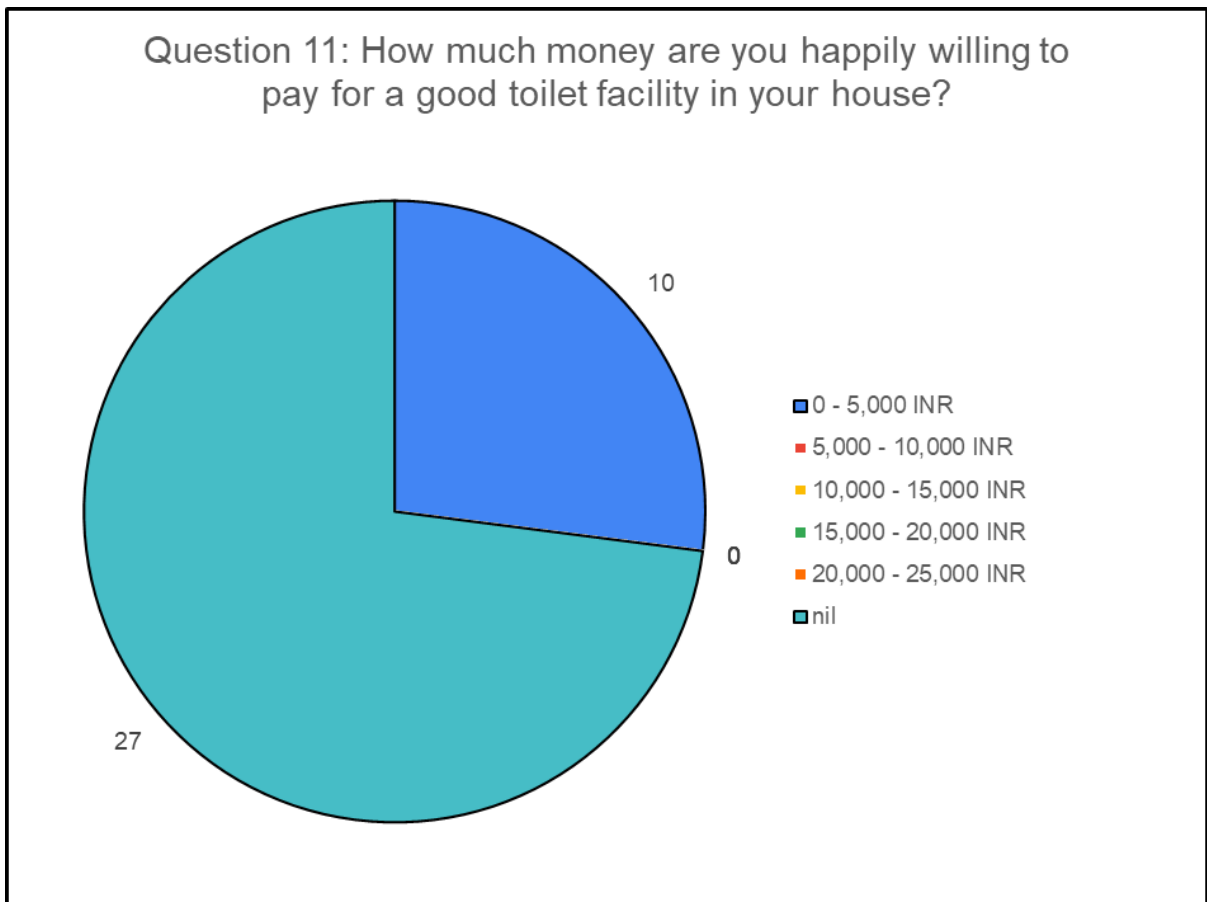


Figure B.7. Response to Question 11 in Appendix A to determine the state of mind of people to pay for the construction of a toilet at their own will

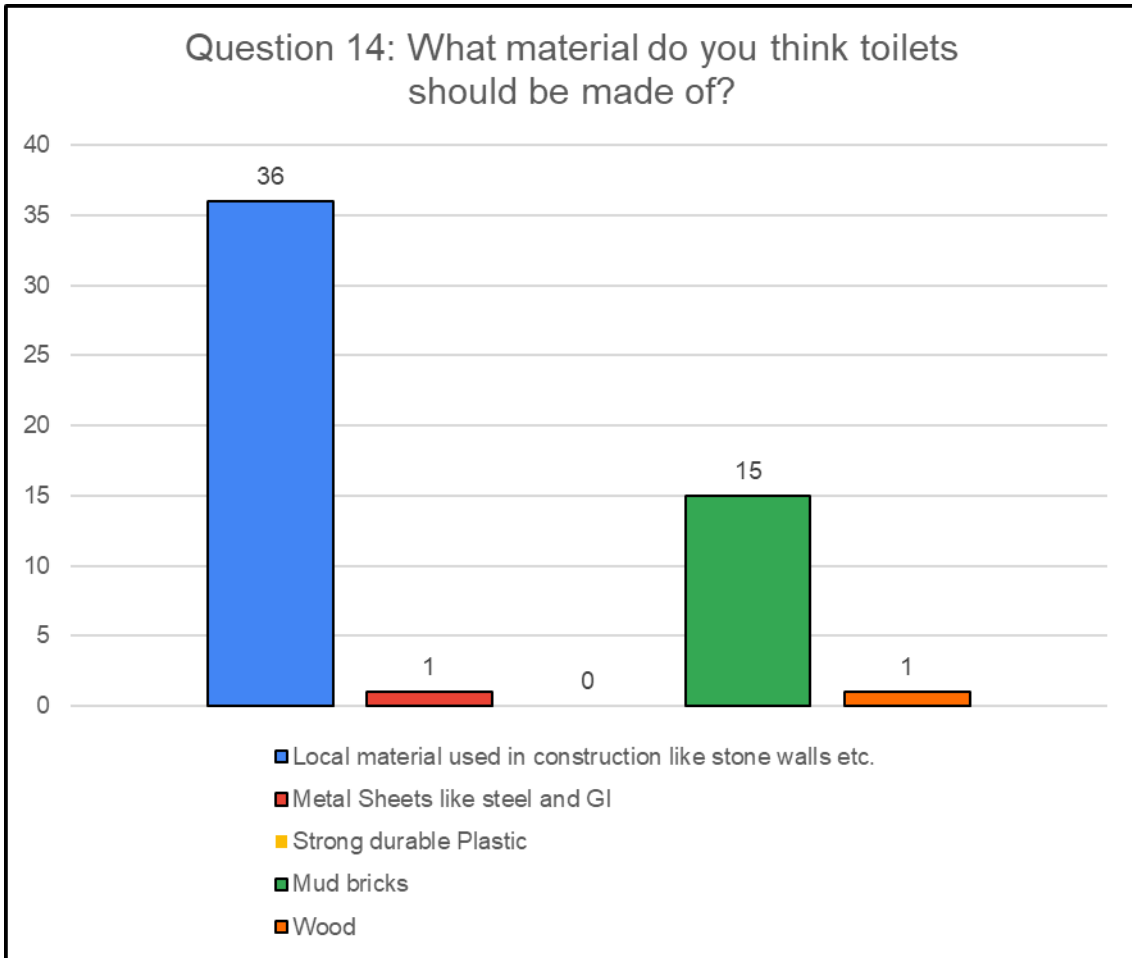


Figure B.8. Response to Question 14 in Appendix A to find out the preferred material for toilet construction

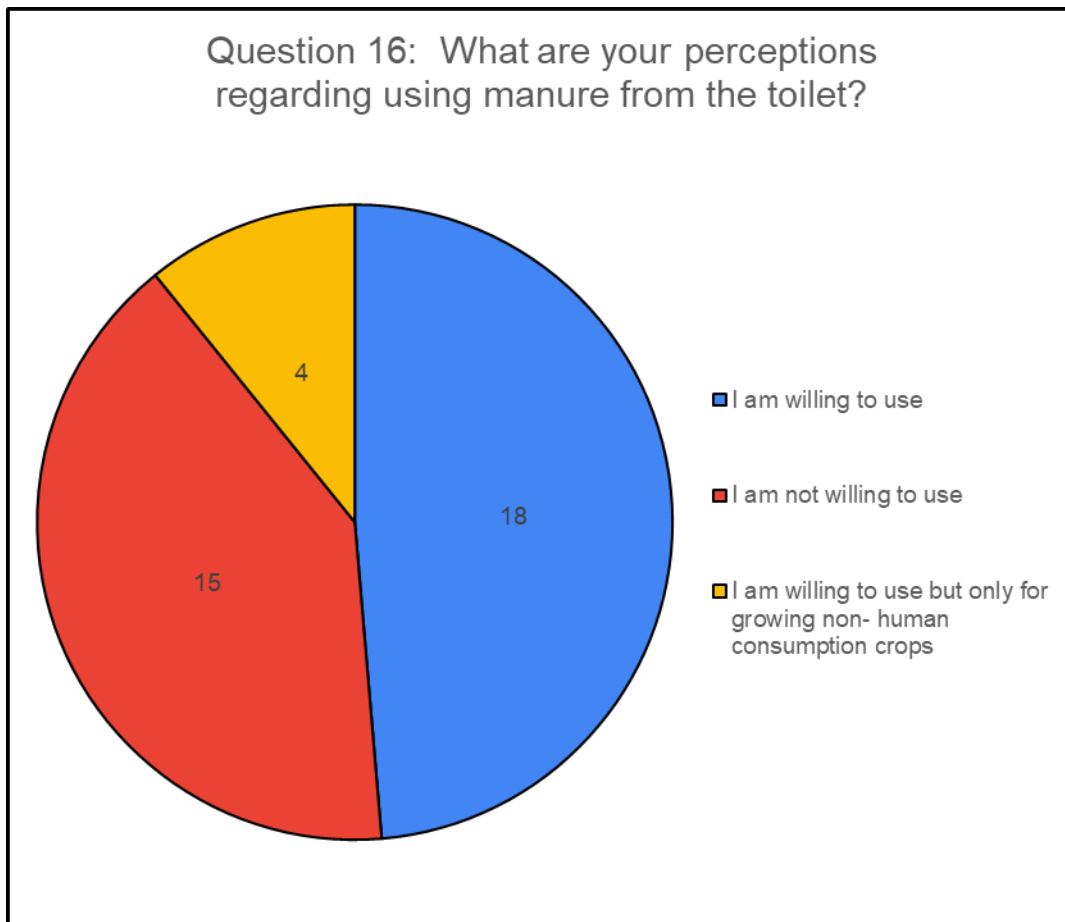


Figure B.9. Willingness to use the manure obtained from the toilet as a response to Question 16 in Appendix A

Appendix C

Results of the cross-table analysis as discussed in Chapter 2

Table C.1. Cross-table analysis between Question 9 and Question 12 (unit: households)

		12. What do you think of toilets which are low in cost and fast to construct?	
		It must be bad/faulty as such a low cost is not possible	Works best for us if someone can provide a facility at less price
9. According to you, how much money does it cost to construct a toilet?	Don't know	4	16
	0-10,000 INR	1	8
	10,000- 20,000 INR	3	3
	20,000- 30,000 INR	0	2

Table C.2. Cross-table analysis between Question 11 and Question 16 (unit: households)

		16. What are your perceptions regarding using manure from the toilet?		
		I am not willing to use	I am willing to use but only for growing non-human consumption crops	I am willing to use
11. How much money	Nil	12	2	12

are you happily willing to pay for a good toilet facility in your house?	0- 5,000 INR	3	1	6
	5,000-10,000 INR	0	0	0
	10,000-15,000 INR	0	1	0

Table C.3. Cross-table analysis between Question 7 and Question 11 (unit: households)

		11. How much money are you happily willing to pay for a good toilet facility in your house?	
		Yes (any value)	Nil
7. Do you intend to pay more expenditure of money than the government's aid for the construction of toilets if it exceeds the subsidy?	Yes	7	3
	No	4	23

Table C.4. Cross-table analysis between Question 15 and Questions 11 and 12 (unit: households)

	11. How much money are you happily willing to pay for a good toilet facility in your house?		12. What do you think of toilets which are low in cost and fast to construct?	
	paying something	paying nothing	Works best for us if	It must be bad/faulty as

				someone can provide a facility at less price	such a low cost is not possible
15. Where do you see advertisements for toilets?	Yes, seen an advertisement	2	14	13	3
	Nope, never saw an advertisement	9	12	16	5

Appendix D.1

Survey Questionnaire (English version)

Hello, my name is Vinayak GUPTA (Mr.), and I am a first-year doctoral student at the Tokyo Institute of Technology, Japan. As a part of my PhD project, I am studying the behaviour of the citizens on the reuse of hydrothermally treated municipal wastes. In layman's language, my project is on converting sewage sludge (SS) into coal pellets. These coal pellets (hydrochar) can be used to light stoves and generate electricity. Imagine that a general waste from your household is used as electricity in your homes or as fuel to cook food. To make this technology accessible and acceptable to the citizens, I have some questions, based on those I, along with other experts in the field, plan to formulate a strategy for its acceptance.



Figure 1: Hydrochar

Part 1: Demographic distribution

The following questions are just for creating the vividness of our respondents and to categorize them. The information from the below questions would not be used in the study.

Your name:

Phone number:

How do you identify yourself with the most?

- Male
- Female
- Others

Your age:

Your locality and city (e.g.: Sector 9, Malaviya Nagar, Jaipur):

Your education level:

- Illiterate
- Primary school (called elementary school in the United States, till class 5 in India)
- Middle school (till class 8 in India)
- Secondary school (called high school in the United States, class 10 or Matrix in India)
- High secondary (class 12)
- College degree/ Graduation (BA, BTech, BBA, MBBS)
- Post-graduation (CA, MA, MS, MTech, MD)
- Doctorate/ Postdoctoral

Your annual income/ family's annual income/

- Below INR 27,000 per annum
- Above INR 27,000 per annum

Are you the sole earning member of your family? Yes/ No

Part 2: Questionnaire part

A five-point Likert scale is being used to evaluate each question in this part of our questionnaire, and the five answers are “1=strongly disagree; 2=disagree; 3=neutrality; 4=agree; 5=strongly agree.” There are no right or wrong answers though.



Figure 2: Characteristic description of hydrochar from sewage

Imagine this now, you have a product in your hand, a kind of coal, which is made up of the sewage sludge (SS). Now answer the following questions and mark those between 1 to 5 wherein 1 would stand that you do not agree with the statement, and 5 would stand that you strongly agree with the said statement.

S. No.	Question	Your response (1 – 5)
AT1	Using hydrochar products can increase my economic income (like using hydrochar as a source of energy in the kitchen rather than LPG gas cylinders).	
AT2	Hydrochar production will alleviate air pollution in rural and urban areas (like there could be less burning of fossil fuels and landfill sites would be reduced).	
AT3	I support the behaviours of acceptance of HSS that contributes to human health.	
AT4	The utilization technologies of hydrothermal carbonization/ hydrochar are environmentally friendly.	
AT5	HSS is necessary to make our environment sustainable.	
SN1	My peer group will think positively of me when they get to know that I am using HSS products.	

SN2	Highly educated neighbours' opinion has a great influence on my decision about hydrochar.	
SN3	Wealthy and influential leaders would approve of the behaviours of HSS use.	
PBC1	I have enough money to adopt the technologies of hydrothermal carbonization/ hydrochar products (about INR 10,000 one-time investment).	
PBC2	I can easily get technical support in the SS hydrothermal carbonization/ hydrochar from industrial technical experts if and whenever I want.	
PBC3	I am confident that I can quickly learn and master the technologies of the usage of HSS.	
IN1	I intend to learn the utilization technologies of SS.	
IN2	I am willing to reuse SS to protect the environment and to be in harmony with nature.	
IN3	I would like to reuse SS to conform to the future development trend of low carbon emissions.	

Comments, if any (Please feel free to share if you have a question which you think we should ask in this survey, or if there is any feedback regarding this survey):

Thank you for being a part of this survey. Being an environmental engineer, I wish to treat and recycle municipal waste so that it can be used as a source of energy. Our team is currently studying ways in which we can help the common masses to accept new and out-of-blue technology. Thank you again for your input in this survey. Your input will eventually help us to formulate strategies and suggest policies to influence the usage of hydrochar.

Appendix D.2

Survey Questionnaire (Hindi version) (for Chapter 4 to 7)

परियोजना के लिए प्रश्रावली कार्बन उत्सर्जन उपशमन के लिए हाइड्रोचर के माध्यम से नगरपालिका ठोस अपशिष्ट का पुनः उपयोग करने के लिए नागरिकों के इरादों पर मनोवैज्ञानिक कारकों का प्रभाव

नमस्ते, मेरा नाम विनायक गुप्ता है, और मैं टोक्यो इंस्टीट्यूट ऑफ टेक्नोलॉजी, जापान में डॉक्टरेट के प्रथम वर्ष का छात्र हूं। मेरी पीएचडी परियोजना के एक भाग के रूप में, मैं हाइड्रोथर्मल रूप से इलाज किए गए नगरपालिका कचरे के पुनः उपयोग पर नागरिकों के व्यवहार का अध्ययन कर रहा हूं। एक आम आदमी की भाषा में, मेरी परियोजना नगरपालिका कीचड़ को कोयले के छर्रों में परिवर्तित करने पर है। इन कोयले के छर्रों (हाइड्रोचार) का उपयोग चूल्हे को जलाने के लिए और बिजली उत्पन्न करने के लिए किया जा सकता है। कल्पना कीजिए कि आपके घर से एक सामान्य अपशिष्ट का उपयोग आपके घरों में बिजली के रूप में या भोजन पकाने के लिए ईंधन के रूप में किया जाता है। इस तकनीक को नागरिकों के लिए सुलभ और स्वीकार्य बनाने के लिए, मेरे पास कुछ प्रश्न हैं जिनके आधार पर मैं, क्षेत्र के अन्य विशेषज्ञों के साथ, इसकी स्वीकृति के लिए एक रणनीति तैयार करने की योजना बना रहा हूं।



चित्र 1: Hydrochar

भाग 1: जनसांख्यिकीय वितरण

निम्नलिखित प्रश्न सिर्फ हमारे नमूनों की स्पष्टता बनाने के लिए हैं, और उन्हें वर्गीकृत करने के लिए हैं। नीचे दिए गए प्रश्नों की जानकारी का उपयोग अध्ययन में नहीं किया जाएगा।

नाम:

फ़ोन नंबर:

आप खुद को सबसे अधिक कैसे पहचानते हैं?

- नर
- मादा
- अन्य

आपकी उम्र:

आपका इलाका और शहर (उदाहरण के लिए: सेक्टर 9, मालवीय नगर, जयपुर):

आपकी शिक्षा का स्तर:

- अशिक्षित
- प्राथमिक विद्यालय (जिसे संयुक्त राज्य अमेरिका में प्राथमिक विद्यालय कहा जाता है, भारत में कक्षा 5 तक)
- मध्य विद्यालय (भारत में कक्षा 8 तक)
- माध्यमिक विद्यालय (संयुक्त राज्य अमेरिका में हाई स्कूल कहा जाता है, कक्षा 10 या भारत में मैट्रिक्स)
- उच्च माध्यमिक (कक्षा 12)
- कॉलेज की डिग्री / स्नातक (बीए, बीटेक, बीबीए, एमबीबीएस)
- स्नातकोत्तर (सीए, एमए, एमएस, एमटेक, एमडी)
- डॉक्टरेट / पोस्टडॉक्टरल

आपकी वार्षिक आय / परिवार की वार्षिक आय /

- INR 27,000 प्रति वर्ष से नीचे
- INR 27,000 प्रति वर्ष से ऊपर

क्या आप अपने परिवार के एकमात्र कमाने वाले सदस्य हैं? हाँ/ नहीं

भाग 2: प्रश्नावली भाग

एक पांच-बिंदु लायकर्ट पैमाने का उपयोग प्रत्येक प्रश्न का मूल्यांकन करने के लिए किया जा रहा है, जो हमारी प्रश्नावली का हिस्सा है, और पांच उत्तर "1 = दृढ़ता से असहमत हैं; 2 = असहमत; 3 = तटस्थता; 4 = सहमत हैं; 5 = दृढ़ता से सहमत हैं। इसके माध्यम से कोई सही या गलत जवाब नहीं है।

अब यह कल्पना कीजिए, आपके हाथ में एक उत्पाद है, एक प्रकार का कोयला, जो नगरपालिका ठोस अपशिष्ट (मल) से बना होता है जिसे आमतौर पर कीचड़ के रूप में जाना जाता है।



चित्र 2: सीवेज से हाइड्रोचर का विशिष्ट विवरण

अब निम्नलिखित प्रश्नों के उत्तर दें और 1 से 5 के बीच उन लोगों को चिह्नित करें जिनमें 1 का मतलब होगा कि आप कथन से सहमत नहीं हैं, 5 का मतलब होगा कि आप उक्त कथन के लिए दृढ़ता से सहमत हैं।

S. No.	प्रश्न	आपकी प्रतिक्रिया (1 - 5)
AT1.	हाइड्रोचर उत्पादों का उपयोग करने से मेरी आर्थिक आय बढ़ सकती है (जैसे एलपीजी गैस सिलेंडरों के बजाय रसोई में ऊर्जा के स्रोत के रूप में हाइड्रोचर का उपयोग करना)।	
AT2	हाइड्रोचर उत्पादन ग्रामीण और शहरी क्षेत्र में वायु प्रदूषण को कम करेगा (जैसे जीवाश्म ईंधन का कम जलना हो सकता है और लैंडफिल साइटों को कम किया जाएगा)।	

AT3	मैं मल हाइड्रोचर की स्वीकृति के व्यवहार का समर्थन करता हूँ जो मानव स्वास्थ्य में योगदान देता है।	
AT4	हाइड्रोथर्मल कार्बोनाइजेशन/हाइड्रोचर की उपयोग प्रौद्योगिकियां पर्यावरण के अनुकूल हैं।	
AT5	मल हाइड्रोचर हमारे पर्यावरण को टिकाऊ बनाने के लिए आवश्यक है।	
SN1	मेरा सहकर्मी समूह मेरे बारे में सकारात्मक सोचेगा जब उन्हें पता चलेगा कि मैं मल हाइड्रोचर उत्पादों का उपयोग कर रहा हूँ।	
SN2	उच्च शिक्षित पड़ोसियों की राय का हाइड्रोचर के बारे में मेरे निर्णय पर बहुत प्रभाव पड़ता है।	
SN3	अमीर और प्रभावशाली नेता मल हाइड्रोचर उपयोग के व्यवहार को मंजूरी देंगे।	
PBC1	मेरे पास हाइड्रोथर्मल कार्बोनाइजेशन / हाइड्रोचर उत्पादों की प्रौद्योगिकियों को अपनाने के लिए पर्याप्त पैसा है।	
PBC2	मैं आसानी से औद्योगिक तकनीकी विशेषज्ञों से मल हाइड्रोथर्मल कार्बोनाइजेशन / हाइड्रोचर में तकनीकी सहायता प्राप्त कर सकता हूँ यदि और जब भी मैं चाहता हूँ।	
PBC3	मुझे विश्वास है कि मैं मल हाइड्रोचर के उपयोग की प्रौद्योगिकियों में महारत हासिल कर सकता हूँ।	
IN1	मैं नगरपालिका ठोस अपशिष्ट के उपयोग प्रौद्योगिकियों को सीखने का इरादा रखता हूँ।	
IN2	मैं पर्यावरण की रक्षा करने और प्रकृति के साथ सद्भाव में रहने के लिए नगरपालिका ठोस अपशिष्ट का पुनः उपयोग करने के लिए तैयार हूँ।	
IN3	मैं कम कार्बन उत्सर्जन के भविष्य के विकास की प्रवृत्ति के अनुरूप नगरपालिका ठोस अपशिष्ट का पुनः उपयोग करना चाहता हूँ।	

टिप्पणियाँ, यदि कोई हो (यदि आपके पास कोई प्रश्न है जो आपको लगता है कि हमें इस सर्वेक्षण में पूछना चाहिए, या यदि इस सर्वेक्षण के बारे में कोई प्रतिक्रिया है तो साझा करने के लिए स्वतंत्र महसूस करें):

इस सर्वेक्षण का हिस्सा बनने के लिए धन्यवाद। एक पर्यावरण इंजीनियर होने के नाते, मैं नगरपालिका अपशिष्ट का इलाज और रीसायकल करना चाहता हूँ ताकि इसका उपयोग ऊर्जा के स्रोत के रूप में किया जा सके। हमारी टीम वर्तमान में उन तरीकों का अध्ययन कर रही है जिनमें हम आम जनता को नई और आउट-ऑफ-ब्लू तकनीक को स्वीकार करने में मदद कर सकते हैं। आप इस सर्वेक्षण में अपने इनपुट के लिए फिर से धन्यवाद। आपका इनपुट अंततः हमें हाइड्रोचर के उपयोग को प्रभावित करने के लिए रणनीतियों को तैयार करने और नीतियों का सुझाव देने में मदद करेगा।

Appendix E

SEM results for SS

Structural Equation Models

Models Info

Estimation Method	DWLS
Optimization Method	NLMINB
Number of observations	72
Free parameters	76
Standard errors	Robust
Scaled test	Mean adjusted scaled and shifted
Converged	TRUE
Iterations	43
Model	AT=~AT1+AT2+AT3+AT4+AT5 SN=~SN1+SN2+SN3 PBC=~PBC1+PBC2+PBC3. IN=~IN1+IN2+IN3

Note. Variable (AT1,AT2,AT3,AT4,AT5,SN1,SN2,SN3,PBC1,PBC2,PBC3,IN1,IN2,IN3) has been coerced to ordered type.

Note. There are missing values in the data and they are removed listwise. Please consider other methods of handling missing values available in Model Options.

Note. lavaan WARNING: Could not compute standard errors! The information matrix could not be inverted. This may be a symptom that the model is not identified.

Note. lavaan WARNING: could not invert information matrix needed for robust test statistic

[3] [4]

Overall Tests

Model tests

Label	χ^2	df	p
User Model	138	67	< .001
Baseline Model	5353	91	< .001
Scaled User	138	67	< .001
Scaled Baseline	1729	91	< .001

fit indices

Type	SRMR	RMSEA	95% Confidence Intervals		RMSEA p
			Lower	Upper	
Classical	0.092	0.122	0.093	0.151	< .001
Robust	0.087				
Scaled	0.087	0.122	0.093	0.151	< .001

	Model
Comparative Fit Index (CFI)	0.987
Tucker-Lewis Index (TLI)	0.982
Bentler-Bonett Non-normed Fit Index (NNFI)	0.982
Relative Noncentrality Index (RNI)	0.987
Bentler-Bonett Normed Fit Index (NFI)	0.974
Bollen's Relative Fit Index (RFI)	0.965
Bollen's Incremental Fit Index (IFI)	0.987
Parsimony Normed Fit Index (PNFI)	0.717

Additional fit indices

	Model
Hoelter Critical N (CN), $\alpha=0.05$	45.880
Hoelter Critical N (CN), $\alpha=0.01$	50.888
Goodness of Fit Index (GFI)	0.979
Adjusted Goodness of Fit Index (AGFI)	0.956
Parsimony Goodness of Fit Index (PGFI)	0.459
McDonald Fit Index (MFI)	0.607
Expected Cross-Validation Index (ECVI)	.
Loglikelihood user model (H0)	.
Loglikelihood unrestricted model (H1)	.
Akaike (AIC)	.
Bayesian (BIC)	.
Sample-size adjusted Bayesian (SABIC)	.

R²

Variable	R ²
AT1	0.419
AT2	0.451
AT3	0.772
AT4	0.557
AT5	0.839
SN1	0.844
SN2	0.567
SN3	0.433
PBC1	0.665
PBC2	0.499
PBC3	0.601
IN1	0.851
IN2	0.883
IN3	0.687

Estimates

Label	Latent	Observed	Estimate	SE	Lower	Upper	β	z	p
p1	AT	AT1	1.000	0.00	1.00	1.00	0.647		
p2		AT2	1.037				0.671		
p3		AT3	1.357				0.879		
p4		AT4	1.153				0.746		
p5		AT5	1.415				0.916		
p6	SN	SN1	1.000	0.00	1.00	1.00	0.919		
p7		SN2	0.820				0.753		
p8		SN3	0.716				0.658		
p9	PBC	PBC1	1.000	0.00	1.00	1.00	0.815		
p10		PBC2	0.866				0.706		
p11		PBC3.	0.951				0.775		
p12	IN	IN1	1.000	0.00	1.00	1.00	0.923		
p13		IN2	1.019				0.940		
p14		IN3	0.898				0.829		

Variances and Covariances

Label	Variable 1	Variable 2	Estimate	SE	95% Confidence Intervals		β	z	p
					Lower	Upper			
p67	AT1	AT1	0.581	0.00	0.581	0.581	0.581		
p68	AT2	AT2	0.549	0.00	0.549	0.549	0.549		
p69	AT3	AT3	0.228	0.00	0.228	0.228	0.228		
p70	AT4	AT4	0.443	0.00	0.443	0.443	0.443		
p71	AT5	AT5	0.161	0.00	0.161	0.161	0.161		
p72	SN1	SN1	0.156	0.00	0.156	0.156	0.156		
p73	SN2	SN2	0.433	0.00	0.433	0.433	0.433		
p74	SN3	SN3	0.567	0.00	0.567	0.567	0.567		
p75	PBC1	PBC1	0.335	0.00	0.335	0.335	0.335		
p76	PBC2	PBC2	0.501	0.00	0.501	0.501	0.501		
p77	PBC3.	PBC3.	0.399	0.00	0.399	0.399	0.399		
p78	IN1	IN1	0.149	0.00	0.149	0.149	0.149		
p79	IN2	IN2	0.117	0.00	0.117	0.117	0.117		
p80	IN3	IN3	0.313	0.00	0.313	0.313	0.313		
p81	AT	AT	0.419				1.000		
p82	SN	SN	0.844				1.000		
p83	PBC	PBC	0.665				1.000		
p84	IN	IN	0.851				1.000		
p85	AT	SN	0.474				0.796		
p86	AT	PBC	0.382				0.723		
p87	AT	IN	0.386				0.647		
p88	SN	PBC	0.437				0.583		
p89	SN	IN	0.736				0.868		
p90	PBC	IN	0.292				0.388		

Label	Variable	Intercept	SE	95% Confidence Intervals		z	p
				Lower	Upper		
p105	AT1	0.000	0.000	0.000	0.000		
p106	AT2	0.000	0.000	0.000	0.000		
p107	AT3	0.000	0.000	0.000	0.000		
p108	AT4	0.000	0.000	0.000	0.000		
p109	AT5	0.000	0.000	0.000	0.000		
p110	SN1	0.000	0.000	0.000	0.000		
p111	SN2	0.000	0.000	0.000	0.000		
p112	SN3	0.000	0.000	0.000	0.000		
p113	PBC1	0.000	0.000	0.000	0.000		
p114	PBC2	0.000	0.000	0.000	0.000		
p115	PBC3	0.000	0.000	0.000	0.000		
p116	IN1	0.000	0.000	0.000	0.000		
p117	IN2	0.000	0.000	0.000	0.000		
p118	IN3	0.000	0.000	0.000	0.000		
p119	AT	0.000					
p120	SN	0.000					
p121	PBC	0.000					
p122	IN	0.000					

Label	Variable	Step	Thresholds	SE	Lower	Upper	z	p
p15	AT1	t1	-1.593					
p16	AT1	t2	-0.355					
p17	AT1	t3	0.967					
p18	AT2	t1	-2.200					
p19	AT2	t2	-0.862					
p20	AT2	t3	0.589					
p21	AT3	t1	-2.200					
p22	AT3	t2	-1.915					
p23	AT3	t3	-0.967					
p24	AT3	t4	0.549					
p25	AT4	t1	-2.200					
p26	AT4	t2	-0.913					
p27	AT4	t3	0.355					
p28	AT5	t1	-2.200					
p29	AT5	t2	-1.732					
p30	AT5	t3	-0.812					
p31	AT5	t4	0.355					
p32	SN1	t1	-1.915					
p33	SN1	t2	-1.298					
p34	SN1	t3	-0.393					
p35	SN1	t4	0.589					
p36	SN2	t1	-1.383					
p37	SN2	t2	-0.549					
p38	SN2	t3	0.070					
p39	SN2	t4	0.967					
p40	SN3	t1	-1.915					
p41	SN3	t2	-1.298					
p42	SN3	t3	-0.210					
p43	SN3	t4	0.913					
p44	PBC1	t1	-2.200					
p45	PBC1	t2	-1.593					
p46	PBC1	t3	-0.549					
p47	PBC1	t4	0.589					
p48	PBC2	t1	-2.200					
p49	PBC2	t2	-0.812					
p50	PBC2	t3	-0.105					
p51	PBC2	t4	1.025					
p52	PBC3.	t1	-2.200					
p53	PBC3.	t2	-0.631					
p54	PBC3.	t3	0.812					
p55	IN1	t1	-1.915					
p56	IN1	t2	-1.480					
p57	IN1	t3	-0.674					
p58	IN1	t4	0.765					
p59	IN2	t1	-1.915					
p60	IN2	t2	-1.480					
p61	IN2	t3	-1.085					
p62	IN2	t4	0.589					
p63	IN3	t1	-1.915					
p64	IN3	t2	-1.593					
p65	IN3	t3	-0.812					
p66	IN3	t4	0.393					

reliability indices

Variable	α	Ordinal α	ω_1	ω_2	ω_3	AVE
AT	0.831	0.881	0.845	0.845	0.846	0.608
SN	0.764	0.820	0.787	0.787	0.784	0.615
PBC	0.730	0.795	0.751	0.751	0.755	0.588
IN	0.899	0.906	0.876	0.876	0.906	0.807

[5]

Covariances and correlations

Observed covariances (lower triangle) and correlations (upper triangle)

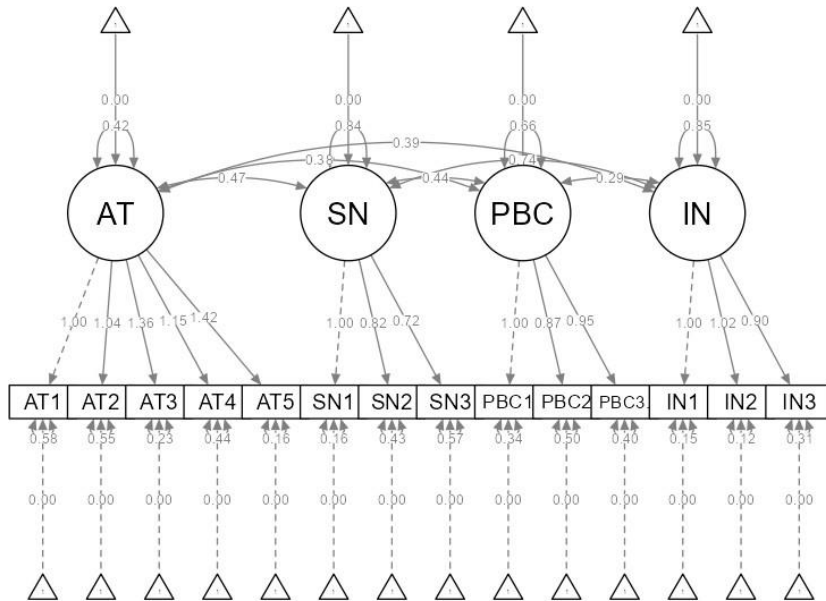
	AT1	AT2	AT3	AT4	AT5	SN1	SN2	SN3	PBC1	PBC2	PBC3.	IN1	IN2	IN3
AT1	1.000	0.416	0.576	0.604	0.478	0.395	0.405	0.244	0.381	0.5435	0.538	0.374	0.345	0.2158
AT2	0.416	1.000	0.705	0.563	0.549	0.391	0.290	0.211	0.395	0.3513	0.473	0.325	0.229	0.3383
AT3	0.576	0.705	1.000	0.677	0.716	0.639	0.495	0.464	0.576	0.3194	0.453	0.436	0.447	0.6034
AT4	0.604	0.563	0.677	1.000	0.687	0.388	0.211	0.290	0.533	0.3466	0.590	0.393	0.326	0.2654
AT5	0.478	0.549	0.716	0.687	1.000	0.830	0.558	0.529	0.389	0.3046	0.416	0.626	0.692	0.6398
SN1	0.395	0.391	0.639	0.388	0.830	1.000	0.631	0.597	0.424	0.3602	0.262	0.720	0.692	0.7105
SN2	0.405	0.290	0.495	0.211	0.558	0.631	1.000	0.582	0.277	0.4249	0.302	0.638	0.660	0.5617
SN3	0.244	0.211	0.464	0.290	0.529	0.597	0.582	1.000	0.409	0.3279	0.128	0.542	0.520	0.4422
PBC1	0.381	0.395	0.576	0.533	0.389	0.424	0.277	0.409	1.000	0.6559	0.471	0.183	0.150	0.3108
PBC2	0.543	0.351	0.319	0.347	0.305	0.360	0.425	0.328	0.656	1.0000	0.564	0.369	0.113	0.0284
PBC3.	0.538	0.473	0.453	0.590	0.416	0.262	0.302	0.128	0.471	0.5644	1.000	0.347	0.313	0.2776
IN1	0.374	0.325	0.436	0.393	0.626	0.720	0.638	0.542	0.183	0.3691	0.347	1.000	0.887	0.6140
IN2	0.345	0.229	0.447	0.326	0.692	0.692	0.660	0.520	0.150	0.1128	0.313	0.887	1.000	0.7850
IN3	0.216	0.338	0.603	0.265	0.640	0.710	0.562	0.442	0.311	0.0284	0.278	0.614	0.785	1.0000

Imputed covariances (lower triangle) and correlations (upper triangle)

	AT1	AT2	AT3	AT4	AT5	SN1	SN2	SN3	PBC1	PBC2	PBC3.	IN1	IN2	IN3
AT1	1.000	0.435	0.569	0.483	0.593	0.474	0.388	0.339	0.382	0.331	0.363	0.386	0.393	0.347
AT2	0.435	1.000	0.590	0.501	0.615	0.491	0.403	0.352	0.396	0.343	0.376	0.401	0.408	0.360
AT3	0.569	0.590	1.000	0.656	0.805	0.643	0.527	0.460	0.518	0.449	0.493	0.524	0.534	0.471
AT4	0.483	0.501	0.656	1.000	0.684	0.546	0.448	0.391	0.440	0.381	0.418	0.445	0.454	0.400
AT5	0.593	0.615	0.805	0.684	1.000	0.670	0.549	0.480	0.540	0.468	0.514	0.547	0.557	0.491
SN1	0.474	0.491	0.643	0.546	0.670	1.000	0.692	0.605	0.437	0.378	0.415	0.736	0.749	0.661
SN2	0.388	0.403	0.527	0.448	0.549	0.692	1.000	0.496	0.358	0.310	0.340	0.603	0.614	0.542
SN3	0.339	0.352	0.460	0.391	0.480	0.605	0.496	1.000	0.313	0.271	0.297	0.527	0.537	0.473
PBC1	0.382	0.396	0.518	0.440	0.540	0.437	0.358	0.313	1.000	0.576	0.632	0.292	0.297	0.262
PBC2	0.331	0.343	0.449	0.381	0.468	0.378	0.310	0.271	0.576	1.000	0.548	0.253	0.257	0.227
PBC3.	0.363	0.376	0.493	0.418	0.514	0.415	0.340	0.297	0.632	0.548	1.000	0.277	0.282	0.249
IN1	0.386	0.401	0.524	0.445	0.547	0.736	0.603	0.527	0.292	0.253	0.277	1.000	0.867	0.765
IN2	0.393	0.408	0.534	0.454	0.557	0.749	0.614	0.537	0.297	0.257	0.282	0.867	1.000	0.779
IN3	0.347	0.360	0.471	0.400	0.491	0.661	0.542	0.473	0.262	0.227	0.249	0.765	0.779	1.000

Path Model

Path diagrams



[6]

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Appendix F

Cross-table analysis results (quantitative) for HSS

Table F: CTA of PBC2 versus SN2 (unit: number of respondents)

		SN2. Highly educated neighbors' opinion has great influence on my decision about hydrochar.				
		5	4	3	2	1
PBC2. I can easily get the technical support in the MSW hydrothermal carbonization/ hydrochar from the industrial technical experts if and whenever I want.	5	7	1	0	2	1
	4	3	16	5	3	2
	3	2	4	7	5	1
	2	0	1	6	5	2
	1	0	1	0	0	0

Appendix G.1

Survey Questionnaire (English version)

Hello, my name is Vinayak GUPTA (Mr.), and I am a first-year doctoral student at the Tokyo Institute of Technology, Japan. As a part of my PhD project, I am studying the behaviour of the citizens on the reuse of hydrothermally treated municipal wastes. In layman's language, my project is on converting municipal solid wastes (MSW) into coal pellets. These coal pellets (hydrochar) can be used to light stoves and generate electricity. Imagine that a general waste from your household is used as electricity in your homes or as fuel to cook food. To make this technology accessible and acceptable to the citizens, I have some questions, based on those I, along with other experts in the field, plan to formulate a strategy for its acceptance.



Figure 1: Hydrochar

Part 1: Demographic distribution

The following questions are just for creating the vividness of our respondents and to categorize them. The information from the below questions would not be used in the study.

Your name:

Phone number:

How do you identify yourself with the most?

- Male
- Female
- Others

Your age:

Your locality and city (e.g.: Sector 9, Malaviya Nagar, Jaipur):

Your education level:

- Illiterate
- Primary school (called elementary school in the United States, till class 5 in India)
- Middle school (till class 8 in India)
- Secondary school (called high school in the United States, class 10 or Matrix in India)
- High secondary (class 12)
- College degree/ Graduation (BA, BTech, BBA, MBBS)
- Post-graduation (CA, MA, MS, MTech, MD)
- Doctorate/ Postdoctoral

Your annual income/ family's annual income/

- Below INR 27,000 per annum
- Above INR 27,000 per annum

Are you the sole earning member of your family? Yes/ No

Part 2: Questionnaire part 1 (dealing with the Hydrochar of municipal solid waste (MSW))

A five-point Likert scale is being used to evaluate each question in this part of our questionnaire, and the five answers are “1=strongly disagree; 2=disagree; 3=neutrality; 4=agree; 5=strongly agree.” There are no right or wrong answers though.

Imagine this now, you have a product in your hand, a kind of coal, which is made up of the municipal solid waste (MSW) commonly known as trash or garbage—consisting of everyday items we use and then throw away, such as product packaging, grass clippings, furniture,

clothing, bottles, food scraps, newspapers, appliances, paint, batteries, etc. This also includes electronic waste which is hazardous and is a major cause of life-threatening diseases like cancer.



Figure 2: Characteristic description of hydrochar made from municipal solid waste

Now answer the following questions and mark those between 1 to 5 wherein 1 would stand that you do not agree with the statement, and 5 would stand that you strongly agree with the said statement.

S. No.	Question	Your response (1 – 5)
AT1	Using hydrochar products can increase my economic income (like using hydrochar as a source of energy in the kitchen rather than LPG gas cylinders).	
AT2	Hydrochar production will alleviate air pollution in rural and urban areas (like there could be less burning of fossil fuels and landfill sites would be reduced).	
AT3	I support the behaviours of acceptance of HMSW that contributes to human health.	
AT4	The utilization technologies of hydrothermal carbonization/ hydrochar are environmentally friendly.	
AT5	HMSW is necessary to make our environment sustainable.	

SN1	My peer group will think positively of me when they get to know that I am using HMSW products.	
SN2	Highly educated neighbours' opinion has a great influence on my decision about hydrochar.	
SN3	Wealthy and influential leaders would approve of the behaviours of HMSW use.	
PBC1	I have enough money to adopt the technologies of hydrothermal carbonization/ hydrochar products (about INR 10,000 one-time investment).	
PBC2	I can easily get technical support in the MSW hydrothermal carbonization/ hydrochar from industrial technical experts if and whenever I want.	
PBC3	I am confident that I can quickly learn and master the technologies of the usage of HMSW.	
IN1	I intend to learn the utilization technologies of MSW.	
IN2	I am willing to reuse MSW to protect the environment and to be in harmony with nature.	
IN3	I would like to reuse MSW to conform to the future development trend of low carbon emissions.	

Comments, if any (Please feel free to share if you have a question which you think we should ask in this survey, or if there is any feedback regarding this survey):

Thank you for being a part of this survey. Being an environmental engineer, I wish to treat and recycle municipal waste so that it can be used as a source of energy. Our team is currently studying ways in which we can help the common masses to accept new and out-of-blue technology. Thank you again for your input in this survey. Your input will eventually help us to formulate strategies and suggest policies to influence the usage of hydrochar.

Appendix G.2

Survey Questionnaire (Hindi version)

परियोजना के लिए प्रश्रावली कार्बन उत्सर्जन उपशमन के लिए हाइड्रोचर के माध्यम से नगरपालिका ठोस अपशिष्ट का पुनः उपयोग करने के लिए नागरिकों के इरादों पर मनोवैज्ञानिक कारकों का प्रभाव

नमस्ते, मेरा नाम विनायक गुप्ता है, और मैं टोक्यो इंस्टीट्यूट ऑफ टेक्नोलॉजी, जापान में डॉक्टरेट के प्रथम वर्ष का छात्र हूं। मेरी पीएचडी परियोजना के एक भाग के रूप में, मैं हाइड्रोथर्मल रूप से इलाज किए गए नगरपालिका कचरे के पुनः उपयोग पर नागरिकों के व्यवहार का अध्ययन कर रहा हूं। एक आम आदमी की भाषा में, मेरी परियोजना नगरपालिका ठोस अपशिष्ट को कोयले के छरों में परिवर्तित करने पर है। इन कोयले के छरों (हाइड्रोचर) का उपयोग चूल्हे को जलाने के लिए और बिजली उत्पन्न करने के लिए किया जा सकता है। कल्पना कीजिए कि आपके घर से एक सामान्य अपशिष्ट का उपयोग आपके घरों में बिजली के रूप में या भोजन पकाने के लिए ईंधन के रूप में किया जाता है। इस तकनीक को नागरिकों के लिए सुलभ और स्वीकार्य बनाने के लिए, मेरे पास कुछ प्रश्न हैं जिनके आधार पर मैं, क्षेत्र के अन्य विशेषज्ञों के साथ, इसकी स्वीकृति के लिए एक रणनीति तैयार करने की योजना बना रहा हूं।



चित्रा 1: Hydrochar

भाग 1: जनसांख्यिकीय वितरण

निम्नलिखित प्रश्न सिर्फ हमारे नमूनों की स्पष्टता बनाने के लिए हैं, और उन्हें वर्गीकृत करने के लिए हैं। नीचे दिए गए प्रश्नों की जानकारी का उपयोग अध्ययन में नहीं किया जाएगा।

नाम:

फ़ोन नंबर:

आप खुद को सबसे अधिक कैसे पहचानते हैं?

- नर
- मादा
- अन्य

आपकी उम्र:

आपका इलाका और शहर (उदाहरण के लिए: सेक्टर 9, मालवीय नगर, जयपुर):

आपकी शिक्षा का स्तर:

- अशिक्षित
- प्राथमिक विद्यालय (जिसे संयुक्त राज्य अमेरिका में प्राथमिक विद्यालय कहा जाता है, भारत में कक्षा 5 तक)
- मध्य विद्यालय (भारत में कक्षा 8 तक)
- माध्यमिक विद्यालय (संयुक्त राज्य अमेरिका में हाई स्कूल कहा जाता है, कक्षा 10 या भारत में मैट्रिक्स)
- उच्च माध्यमिक (कक्षा 12)
- कॉलेज की डिग्री / स्नातक (बीए, बीटेक, बीबीए, एमबीबीएस)
- स्नातकोत्तर (सीए, एमए, एमएस, एमटेक, एमडी)
- डॉक्टरेट / पोस्टडॉक्टरल

आपकी वार्षिक आय / परिवार की वार्षिक आय /

- INR 27,000 प्रति वर्ष से नीचे
- INR 27,000 प्रति वर्ष से ऊपर

क्या आप अपने परिवार के एकमात्र कमाने वाले सदस्य हैं? हाँ/ नहीं

भाग 2: प्रश्नावली भाग 1 (नगरपालिका ठोस अपशिष्ट (एमएसडब्ल्यू) के हाइड्रोचर से निपटना)

एक पांच-बिंदु लायकर्ट पैमाने का उपयोग प्रत्येक प्रश्न का मूल्यांकन करने के लिए किया जा रहा है, जो हमारी प्रश्नावली का हिस्सा है, और पांच उत्तर "1 = दृढ़ता से असहमत हैं; 2 = असहमत; 3 = तटस्थता; 4 = सहमत हैं; 5 = दृढ़ता से सहमत हैं। इसके माध्यम से कोई सही या गलत जवाब नहीं है।

अब यह कल्पना कीजिए, आपके हाथ में एक उत्पाद है, एक प्रकार का कोयला, जो नगरपालिका ठोस अपशिष्ट है।



चित्र 2: नगरपालिका के ठोस अपशिष्ट से बने हाइड्रोचर का विशिष्ट विवरण

अब निम्नलिखित प्रश्नों के उत्तर दें और 1 से 5 के बीच उन लोगों को चिह्नित करें जिनमें 1 का मतलब होगा कि आप कथन से सहमत नहीं हैं, 5 का मतलब होगा कि आप उक्त कथन के लिए दृढ़ता से सहमत हैं।

S. No.	प्रश्न	आपकी प्रतिक्रिया (1 - 5)
AT1.	हाइड्रोचर उत्पादों का उपयोग करने से मेरी आर्थिक आय बढ़ सकती है (जैसे एलपीजी गैस सिलेंडरों के बजाय रसोई में ऊर्जा के स्रोत के रूप में हाइड्रोचर का उपयोग करना)।	
AT2	हाइड्रोचर उत्पादन ग्रामीण और शहरी क्षेत्र में वायु प्रदूषण को कम करेगा (जैसे जीवाश्म ईंधन का कम जलना हो सकता है और लैंडफिल साइटों को कम किया जाएगा)।	
AT3	मैं अपशिष्ट हाइड्रोचर की स्वीकृति के व्यवहार का समर्थन करता हूँ जो मानव स्वास्थ्य में योगदान देता है।	

AT4	हाइड्रोथर्मल कार्बोनाइजेशन/हाइड्रोचर की उपयोग प्रौद्योगिकियां पर्यावरण के अनुकूल हैं।	
AT5	अपशिष्ट हाइड्रोचर हमारे पर्यावरण को टिकाऊ बनाने के लिए आवश्यक है।	
SN1	मेरा सहकर्मी समूह मेरे बारे में सकारात्मक सोचेगा जब उन्हें पता चलेगा कि मैं अपशिष्ट हाइड्रोचर उत्पादों का उपयोग कर रहा हूँ।	
SN2	उच्च शिक्षित पड़ोसियों की राय का हाइड्रोचर के बारे में मेरे निर्णय पर बहुत प्रभाव पड़ता है।	
SN3	अमीर और प्रभावशाली नेता अपशिष्ट हाइड्रोचर उपयोग के व्यवहार को मंजूरी देंगे।	
PBC1	मेरे पास हाइड्रोथर्मल कार्बोनाइजेशन / हाइड्रोचर उत्पादों की प्रौद्योगिकियों को अपनाने के लिए पर्याप्त पैसा है।	
PBC2	मैं आसानी से औद्योगिक तकनीकी विशेषज्ञों से अपशिष्ट हाइड्रोथर्मल कार्बोनाइजेशन / हाइड्रोचर में तकनीकी सहायता प्राप्त कर सकता हूँ यदि और जब भी मैं चाहता हूँ।	
PBC3	मुझे विश्वास है कि मैं अपशिष्ट हाइड्रोचर के उपयोग की प्रौद्योगिकियों में महारत हासिल कर सकता हूँ।	
IN1	मैं नगरपालिका ठोस अपशिष्ट के उपयोग प्रौद्योगिकियों को सीखने का इरादा रखता हूँ।	
IN2	मैं पर्यावरण की रक्षा करने और प्रकृति के साथ सद्भाव में रहने के लिए नगरपालिका ठोस अपशिष्ट का पुनः उपयोग करने के लिए तैयार हूँ।	
IN3	मैं कम कार्बन उत्सर्जन के भविष्य के विकास की प्रवृत्ति के अनुरूप नगरपालिका ठोस अपशिष्ट का पुनः उपयोग करना चाहता हूँ।	

टिप्पणियाँ, यदि कोई हो (यदि आपके पास कोई प्रश्न है जो आपको लगता है कि हमें इस सर्वेक्षण में पूछना चाहिए, या यदि इस सर्वेक्षण के बारे में कोई प्रतिक्रिया है तो साझा करने के लिए स्वतंत्र महसूस करें):

इस सर्वेक्षण का हिस्सा बनने के लिए धन्यवाद। एक पर्यावरण इंजीनियर होने के नाते, मैं नगरपालिका अपशिष्ट का इलाज और रीसायकल करना चाहता हूँ ताकि इसका उपयोग ऊर्जा के स्रोत के रूप में किया जा सके। हमारी टीम

वर्तमान में उन तरीकों का अध्ययन कर रही है जिनमें हम आम जनता को नई और आउट-ऑफ-ब्लू तकनीक को स्वीकार करने में मदद कर सकते हैं। आप इस सर्वेक्षण में अपने इनपुट के लिए फिर से धन्यवाद। आपका इनपुट अंततः हमें हाइड्रोचर के उपयोग को प्रभावित करने के लिए रणनीतियों को तैयार करने और नीतियों का सुझाव देने में मदद करेगा।

Appendix H

SEM results for MSW

Structural Equation Models

Models Info

Estimation Method	DWLS
Optimization Method	NLMINB
Number of observations	74
Free parameters	72
Standard errors	Robust
Scaled test	Mean adjusted scaled and shifted
Converged	TRUE
Iterations	43
Model	AT= ~AT1+AT2+AT3+AT4+AT5 SN= ~SN1+SN2+SN3 PBC= ~PBC1+PBC2+PBC3 IN= ~IN1+IN2+IN3

Note. Variable (AT1,AT2,AT3,AT4,AT5,SN1,SN2,SN3,PBC1,PBC2,PBC3,IN1,IN2,IN3) has been coerced to ordered type.

Note. lavaan WARNING: The variance-covariance matrix of the estimated parameters (vcov) does not appear to be positive definite! The smallest eigenvalue (= -7.234525e-17) is smaller than zero. This may be a symptom that the model is not identified.

[3] [4]

Overall Tests

Model tests

Label	χ^2	df	p
User Model	88.1	71	0.082
Baseline Model	2028.3	91	< .001
Scaled User	123.0	71	< .001
Scaled Baseline	925.5	91	< .001

Fit indices

Type	SRMR	RMSEA	95% Confidence Intervals		RMSEA p
			Lower	Upper	
Classical	0.084	0.057	0.000	0.093	0.364
Robust	0.079				
Scaled	0.079	0.100	0.070	0.129	0.006

User model versus baseline model

	Model
Comparative Fit Index (CFI)	0.991
Tucker-Lewis Index (TLI)	0.989
Bentler-Bonett Non-normed Fit Index (NNFI)	0.989
Relative Noncentrality Index (RNI)	0.991
Bentler-Bonett Normed Fit Index (NFI)	0.957
Bollen's Relative Fit Index (RFI)	0.944
Bollen's Incremental Fit Index (IFI)	0.991
Parsimony Normed Fit Index (PNFI)	0.746

Estimates

Measurement model

Latent	Observed	Estimate	SE	95% Confidence Intervals		β	z	p
				Lower	Upper			
AT	AT1	1.000	0.0000	1.000	1.000	0.738		
	AT2	0.602	0.1273	0.352	0.851	0.444	4.73	< .001
	AT3	0.968	0.1386	0.697	1.240	0.715	6.99	< .001
	AT4	0.945	0.1203	0.709	1.181	0.697	7.85	< .001
	AT5	1.045	0.1218	0.806	1.284	0.771	8.57	< .001
SN	SN1	1.000	0.0000	1.000	1.000	0.848		
	SN2	0.953	0.0700	0.815	1.090	0.808	13.62	< .001
	SN3	0.739	0.0871	0.568	0.909	0.627	8.48	< .001
PBC	PBC1	1.000	0.0000	1.000	1.000	0.452		
	PBC2	1.851	0.4642	0.941	2.761	0.837	3.99	< .001
	PBC3	1.178	0.3687	0.455	1.900	0.532	3.19	0.001
IN	IN1	1.000	0.0000	1.000	1.000	0.864		
	IN2	0.904	0.0967	0.714	1.093	0.781	9.35	< .001
	IN3	1.073	0.0951	0.887	1.260	0.928	11.29	< .001

Variances and Covariances

Variable 1	Variable 2	Estimate	SE	95% Confidence Intervals		β	z	p
				Lower	Upper			
AT1	AT1	0.456	0.0000	0.4556	0.456	0.456		
AT2	AT2	0.803	0.0000	0.8030	0.803	0.803		
AT3	AT3	0.489	0.0000	0.4894	0.489	0.489		
AT4	AT4	0.514	0.0000	0.5137	0.514	0.514		
AT5	AT5	0.406	0.0000	0.4058	0.406	0.406		
SN1	SN1	0.280	0.0000	0.2804	0.280	0.280		
SN2	SN2	0.347	0.0000	0.3470	0.347	0.347		
SN3	SN3	0.607	0.0000	0.6073	0.607	0.607		
PBC1	PBC1	0.796	0.0000	0.7956	0.796	0.796		
PBC2	PBC2	0.300	0.0000	0.2996	0.300	0.300		
PBC3	PBC3	0.717	0.0000	0.7165	0.717	0.717		
IN1	IN1	0.253	0.0000	0.2528	0.253	0.253		
IN2	IN2	0.390	0.0000	0.3895	0.390	0.390		
IN3	IN3	0.139	0.0000	0.1392	0.139	0.139		
AT	AT	0.544	0.1013	0.3459	0.743	1.000	5.37	< .001
SN	SN	0.720	0.0927	0.5379	0.901	1.000	7.76	< .001
PBC	PBC	0.204	0.0854	0.0370	0.372	1.000	2.39	0.017
IN	IN	0.747	0.1139	0.5240	0.970	1.000	6.56	< .001
AT	SN	0.488	0.0672	0.3567	0.620	0.780	7.27	< .001
AT	PBC	0.257	0.0720	0.1162	0.399	0.772	3.57	< .001
AT	IN	0.311	0.0716	0.1704	0.451	0.487	4.34	< .001
SN	PBC	0.203	0.0657	0.0747	0.332	0.531	3.10	0.002
SN	IN	0.535	0.0644	0.4089	0.661	0.730	8.31	< .001
PBC	IN	0.140	0.0613	0.0196	0.260	0.357	2.28	0.023

Intercepts

Variable	Intercept	SE	95% Confidence Intervals		z	p
			Lower	Upper		
AT1	0.000	0.000	0.000	0.000		
AT2	0.000	0.000	0.000	0.000		
AT3	0.000	0.000	0.000	0.000		
AT4	0.000	0.000	0.000	0.000		
AT5	0.000	0.000	0.000	0.000		
SN1	0.000	0.000	0.000	0.000		
SN2	0.000	0.000	0.000	0.000		
SN3	0.000	0.000	0.000	0.000		
PBC1	0.000	0.000	0.000	0.000		
PBC2	0.000	0.000	0.000	0.000		
PBC3	0.000	0.000	0.000	0.000		
IN1	0.000	0.000	0.000	0.000		
IN2	0.000	0.000	0.000	0.000		
IN3	0.000	0.000	0.000	0.000		
AT	0.000	0.000	0.000	0.000		
SN	0.000	0.000	0.000	0.000		
PBC	0.000	0.000	0.000	0.000		
IN	0.000	0.000	0.000	0.000		

Thresholds

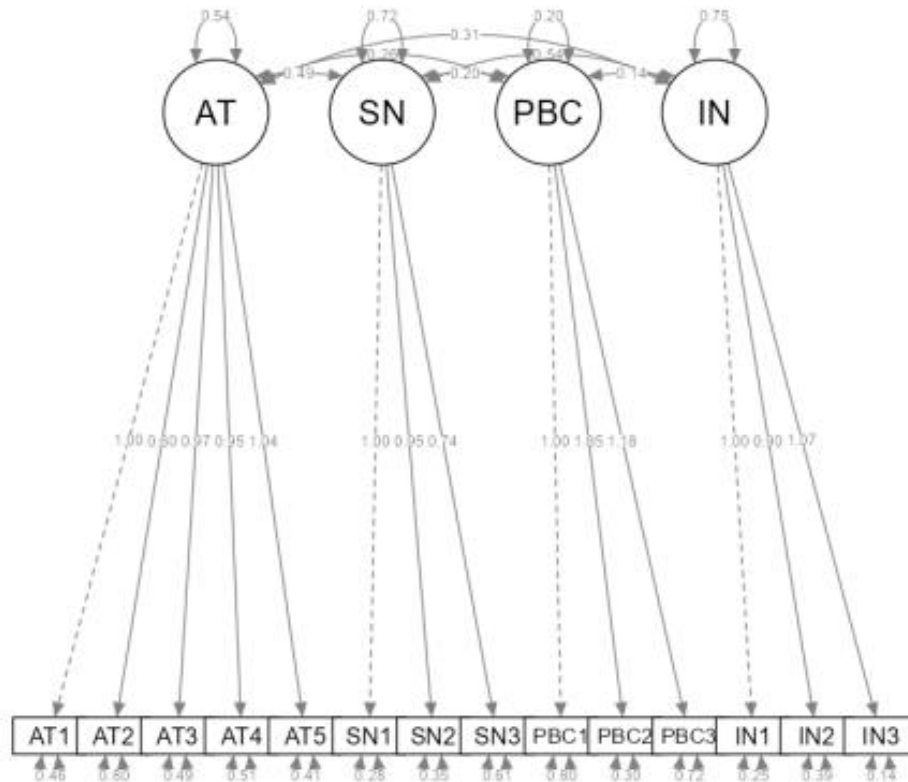
Variable	Step	Thresholds	SE	95% Confidence Intervals		z	p
				Lower	Upper		
AT1	t1	-1.744	0.265	-2.264	-1.225	-6.584	< .001
AT1	t2	-0.456	0.152	-0.754	-0.157	-2.991	0.003
AT1	t3	0.653	0.159	0.342	0.964	4.118	< .001
AT2	t1	-1.607	0.241	-2.079	-1.134	-6.662	< .001
AT2	t2	-1.167	0.189	-1.538	-0.796	-6.160	< .001
AT2	t3	-0.696	0.160	-1.010	-0.382	-4.340	< .001
AT2	t4	0.832	0.167	0.505	1.159	4.990	< .001
AT3	t1	-2.211	0.390	-2.976	-1.446	-5.664	< .001
AT3	t2	-0.986	0.176	-1.330	-0.641	-5.608	< .001
AT3	t3	0.532	0.154	0.229	0.835	3.445	< .001
AT4	t1	-1.926	0.304	-2.523	-1.330	-6.332	< .001
AT4	t2	-0.740	0.162	-1.058	-0.422	-4.559	< .001
AT4	t3	0.310	0.149	0.017	0.602	2.075	0.038
AT5	t1	-1.926	0.304	-2.523	-1.330	-6.332	< .001
AT5	t2	-1.607	0.241	-2.079	-1.134	-6.662	< .001
AT5	t3	-0.785	0.164	-1.107	-0.463	-4.776	< .001
AT5	t4	0.653	0.159	0.342	0.964	4.118	< .001
SN1	t1	-1.926	0.304	-2.523	-1.330	-6.332	< .001
SN1	t2	-1.237	0.196	-1.620	-0.853	-6.319	< .001
SN1	t3	-0.345	0.150	-0.639	-0.052	-2.305	0.021
SN1	t4	0.696	0.160	0.382	1.010	4.340	< .001
SN2	t1	-1.313	0.203	-1.711	-0.915	-6.458	< .001
SN2	t2	-0.612	0.157	-0.920	-0.304	-3.895	< .001
SN2	t3	0.000	0.147	-0.288	0.288	0.000	1.000
SN2	t4	1.042	0.180	0.690	1.394	5.801	< .001
SN3	t1	-1.926	0.304	-2.523	-1.330	-6.332	< .001
SN3	t2	-1.237	0.196	-1.620	-0.853	-6.319	< .001
SN3	t3	-0.274	0.149	-0.566	0.017	-1.845	0.065
SN3	t4	0.653	0.159	0.342	0.964	4.118	< .001
PBC1	t1	-1.926	0.304	-2.523	-1.330	-6.332	< .001
PBC1	t2	-1.313	0.203	-1.711	-0.915	-6.458	< .001
PBC1	t3	-0.136	0.147	-0.424	0.153	-0.923	0.356
PBC1	t4	1.237	0.196	0.853	1.620	6.319	< .001
PBC2	t1	-1.398	0.213	-1.815	-0.981	-6.571	< .001
PBC2	t2	-0.572	0.156	-0.877	-0.266	-3.670	< .001
PBC2	t3	0.068	0.147	-0.220	0.356	0.462	0.644
PBC2	t4	1.313	0.203	0.915	1.711	6.458	< .001
PBC3	t1	-1.926	0.304	-2.523	-1.330	-6.332	< .001
PBC3	t2	-0.696	0.160	-1.010	-0.382	-4.340	< .001
PBC3	t3	0.653	0.159	0.342	0.964	4.118	< .001
IN1	t1	-2.211	0.390	-2.976	-1.446	-5.664	< .001
IN1	t2	-1.607	0.241	-2.079	-1.134	-6.662	< .001
IN1	t3	-1.102	0.184	-1.463	-0.741	-5.986	< .001
IN1	t4	0.494	0.153	0.193	0.794	3.218	0.001
IN2	t1	-1.926	0.304	-2.523	-1.330	-6.332	< .001
IN2	t2	-1.607	0.241	-2.079	-1.134	-6.662	< .001
IN2	t3	-1.237	0.196	-1.620	-0.853	-6.319	< .001
IN2	t4	0.274	0.149	-0.017	0.566	1.845	0.065
IN3	t1	-1.926	0.304	-2.523	-1.330	-6.332	< .001
IN3	t2	-1.744	0.265	-2.264	-1.225	-6.584	< .001
IN3	t3	-1.042	0.180	-1.394	-0.690	-5.801	< .001

Thresholds

Variable	Step	Thresholds	SE	95% Confidence Intervals		z	p
				Lower	Upper		
IN3	14	0.310	0.149	0.017	0.602	2.075	0.038

Path Model

Path diagrams



[5]

References

- [1] The jamovi project (2022). *jamovi*. (Version 2.3) [Computer Software]. Retrieved from <https://www.jamovi.org>.
- [2] R Core Team (2021). *R: A Language and environment for statistical computing*. (Version 4.1) [Computer software]. Retrieved from <https://cran.r-project.org>, (R packages retrieved from MRAN snapshot 2022-01-01).
- [3] Gallucci, M., Jentschke, S. (2021). *SEML: jamovi SEM Analysis*. [jamovi module]. For help please visit <https://semli.github.io/>.
- [4] Rosseel, Y. (2019). lavaan: An R Package for Structural Equation Modeling. *Journal of Statistical Software*, 48(2), 1-36. [link](#).
- [5] Epskamp S., Stuber S., Nak J., Veenman M., Jorgensen T.D. (2019). *semPlot: Path Diagrams and Visual Analysis of Various SEM Packages' Output*. [R Package]. Retrieved from <https://CRAN.R-project.org/package=semPlot>.

Appendix I

Cross-table analysis results (quantitative) for HMSW

Table I.1: CTA of AT2 versus SN1 (unit: number of respondents)

		AT2. Hydrochar production will alleviate air pollution in rural and urban areas (like there could be less burning of fossil fuels and landfill sites would be reduced).				
		5	4	3	2	1
SN1. My peer group will think positively of me when they get to know that I am using MSW Hydrochar products.	5	9	8	0	0	1
	4	1	19	3	4	2
	3	3	11	3	1	1
	2	1	2	3	0	0
	1	1	1	0	0	0

Table I.2: CTA of SN2 versus PBC2 (unit: number of respondents)

		SN2. Highly educated neighbours' opinion has a great influence on my decision about hydrochar.				
		5	4	3	2	1
PBC2. I can easily get technical support in the MSW hydrothermal carbonization/ hydrochar from	5	5	1	0	0	1
	4	3	16	3	3	3
	3	2	4	7	4	1

industrial technical experts if and whenever I want.	2	1	4	4	4	2
	1	0	1	3	2	0

Table I.3: CTA of SN3 versus PBC2 (unit: number of respondents)

		SN3. Wealthy and influential leaders would approve of the behaviours of MSW hydrochar use.				
		5	4	3	2	1
PBC2. I can easily get technical support in the MSW hydrothermal carbonization / hydrochar from industrial technical experts if and whenever I want.	5	6	1	0	0	0
	4	4	15	7	0	2
	3	3	3	10	2	0
	2	4	5	4	2	0
	1	2	2	0	2	0

Table I.4: CTA of AT2 versus PBC2 (unit: number of respondents)

		AT2. Hydrochar production will alleviate air pollution in rural and urban areas (like there could be less burning of fossil fuels and landfill sites would be reduced).				
		5	4	3	2	1
PBC2. I can easily get technical support in the MSW hydrotherma	5	6	1	0	0	0
	4	4	22	1	1	0

I carbonization / hydrochar from industrial technical experts if and whenever I want.	3	2	9	2	3	2
	2	2	7	4	1	1
	1	1	2	2	0	1

Table I.5: CTA of IN2 versus PBC2 (unit: number of respondents)

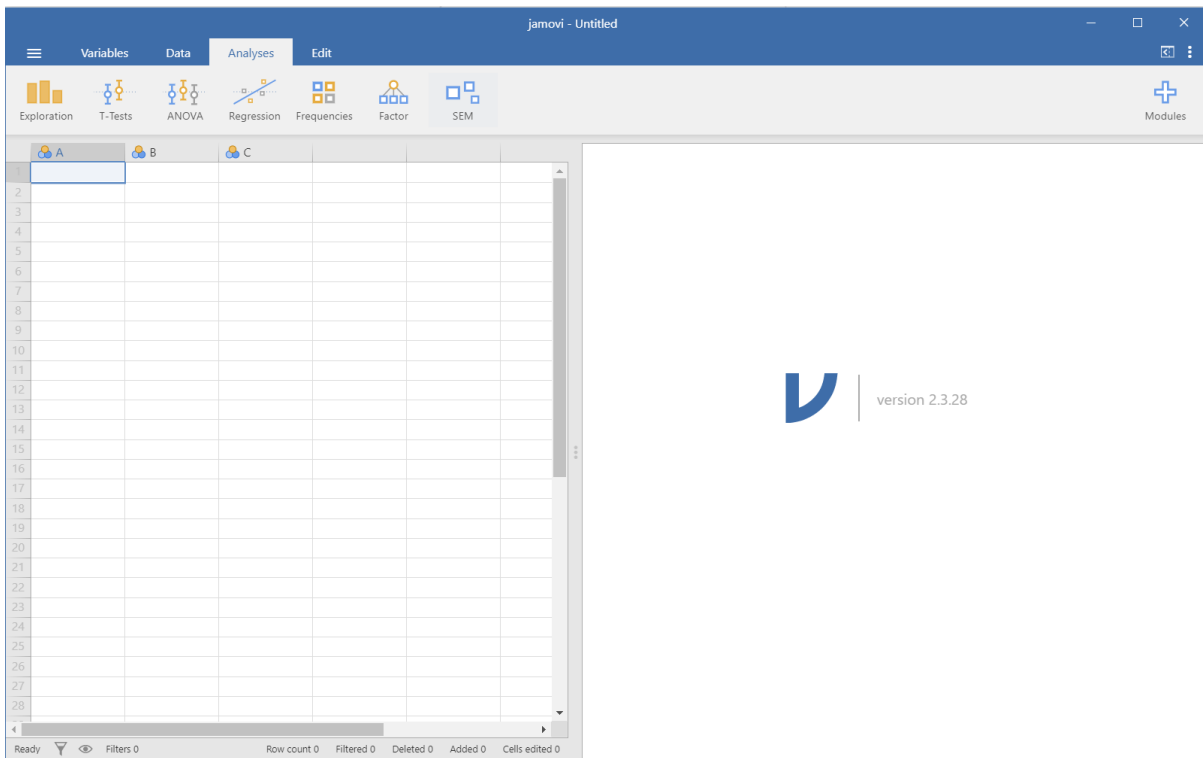
		IN2. I am willing to reuse MSW to protect the environment and to be in harmony with nature.				
		5	4	3	2	1
PBC2. I can easily get technical support in the MSW hydrothermal carbonization / hydrochar from industrial technical experts if and whenever I want.	5	5	1	1	0	0
	4	8	17	1	0	2
	3	6	11	1	0	0
	2	9	6	0	0	0
	1	1	2	1	2	0

Appendix J.1

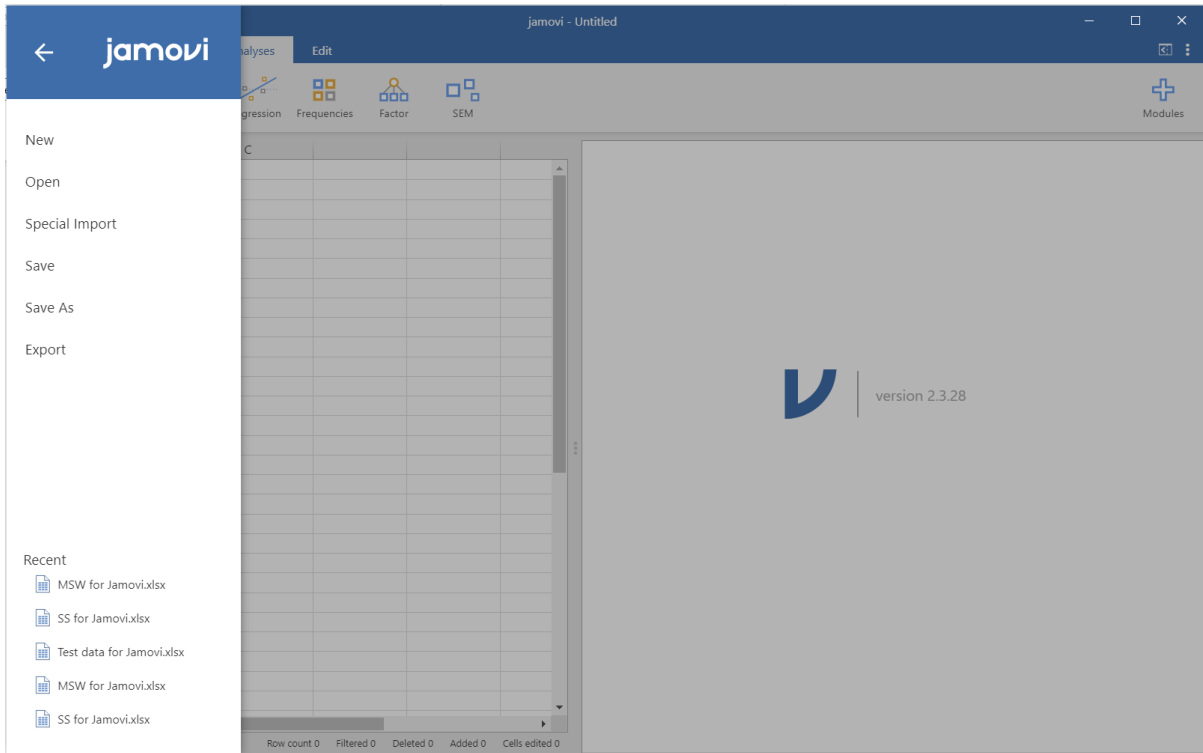
Steps taken in Jamovi for calculation of chi-square test results

The software “Jamovi” (version 2.2.5) was used to find out the value of the chi-square test. Here are the steps followed.

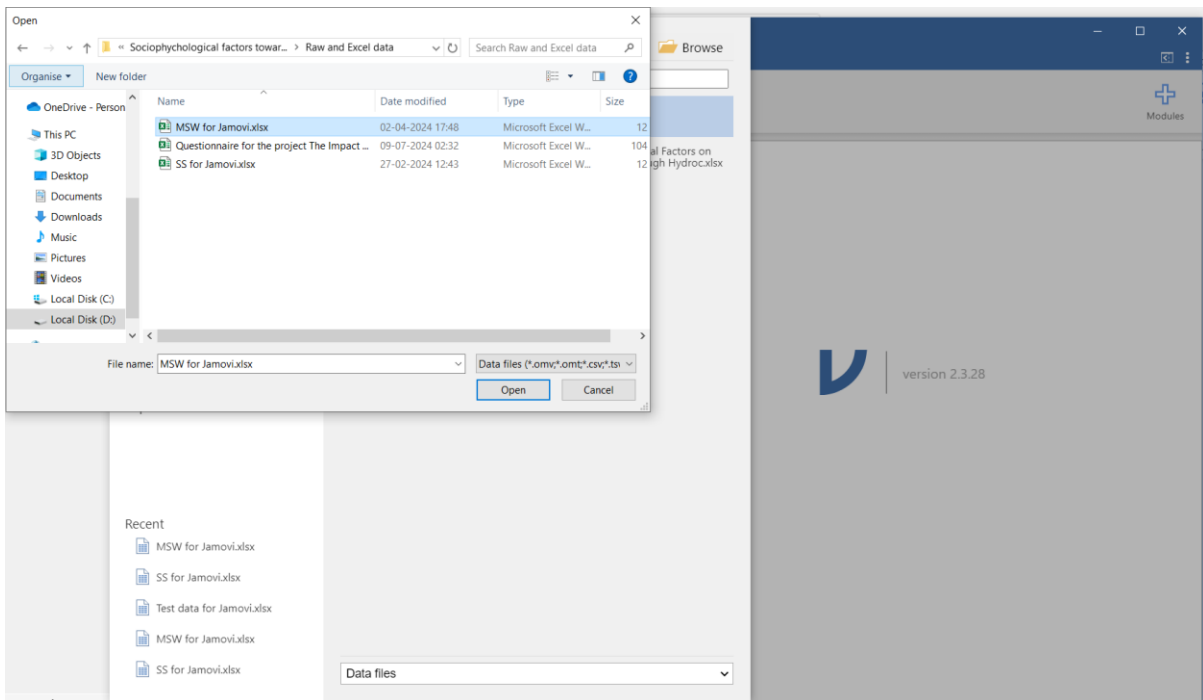
1. Open Jamovi software, the following screen is shown.



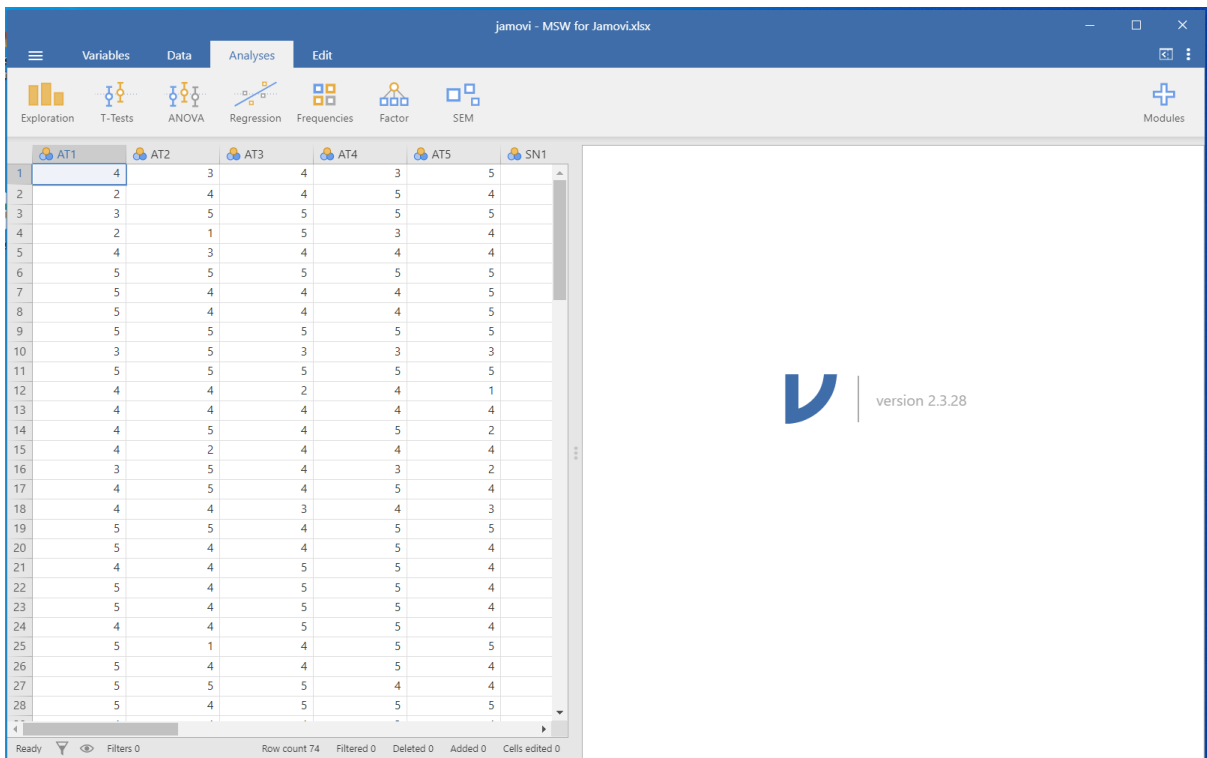
2. Click on the three lines in the top left corner, and select “open” to open your data.



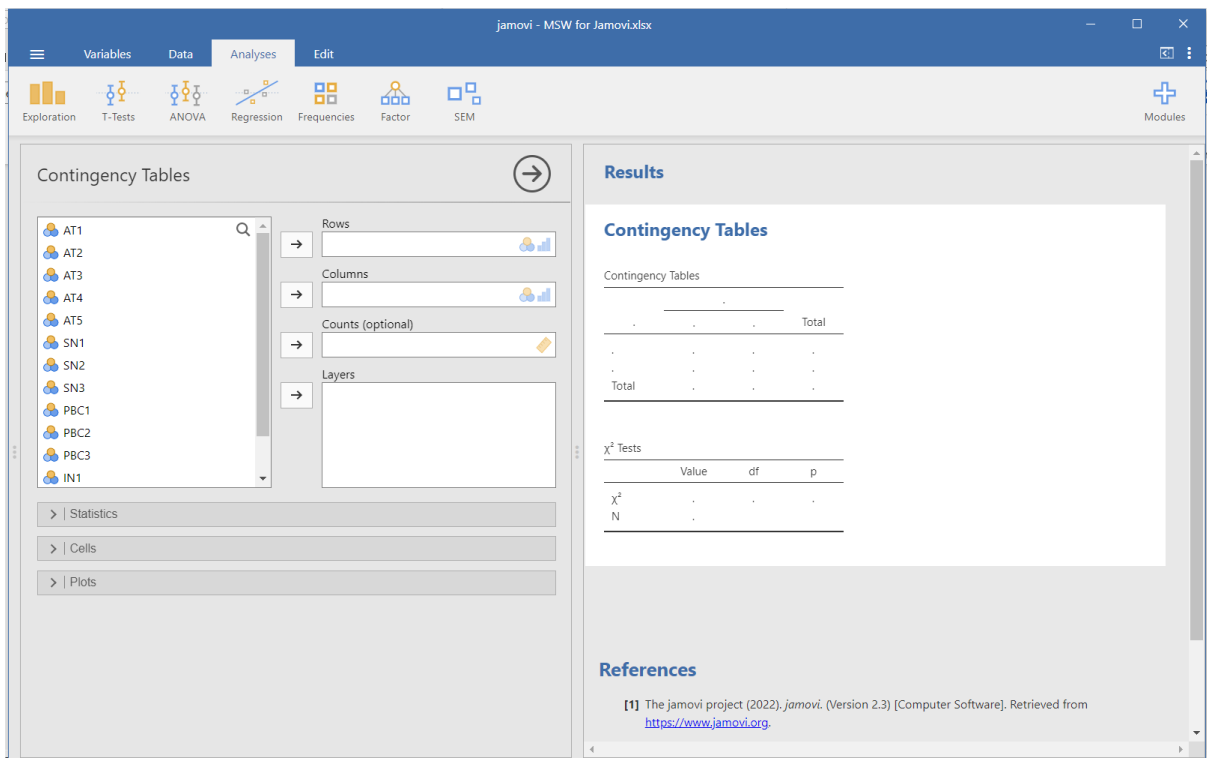
3. Click on “Browse”, and locate and select the Excel file which contains your data.



4. Click on “Open”. You will see the following screen. Notice that the question types (AT1, AT2, AT3...) have automatically become column headings.



5. Click on the “independent samples χ^2 test of association” under the tab Frequencies. Following screen is visible.



6. Select the two items for which you want to conduct the chi-square test and click on the arrows to put them under Rows and Columns. For example, let us consider PBC2 and SN1.

The screenshot shows the Jamovi software interface with the 'Analyses' tab selected. The 'Contingency Tables' panel on the left lists variables: AT1, AT2, AT3, AT4, AT5, SN2, SN3, PBC1, PBC3, IN1, IN2, and IN3. The 'Rows' field contains SN1 and the 'Columns' field contains PBC2. The 'Results' panel on the right displays the following contingency table:

SN1	PBC2					Total
	1	2	3	4	5	
1	0	0	0	2	0	2
2	1	2	1	2	0	6
3	3	6	5	4	1	19
4	2	6	9	11	1	29
5	0	1	3	9	5	18
Total	6	15	18	28	7	74

Below the contingency table, the χ^2 Tests table is shown:

	Value	df	p
χ^2	22.1	16	0.141
N	74		

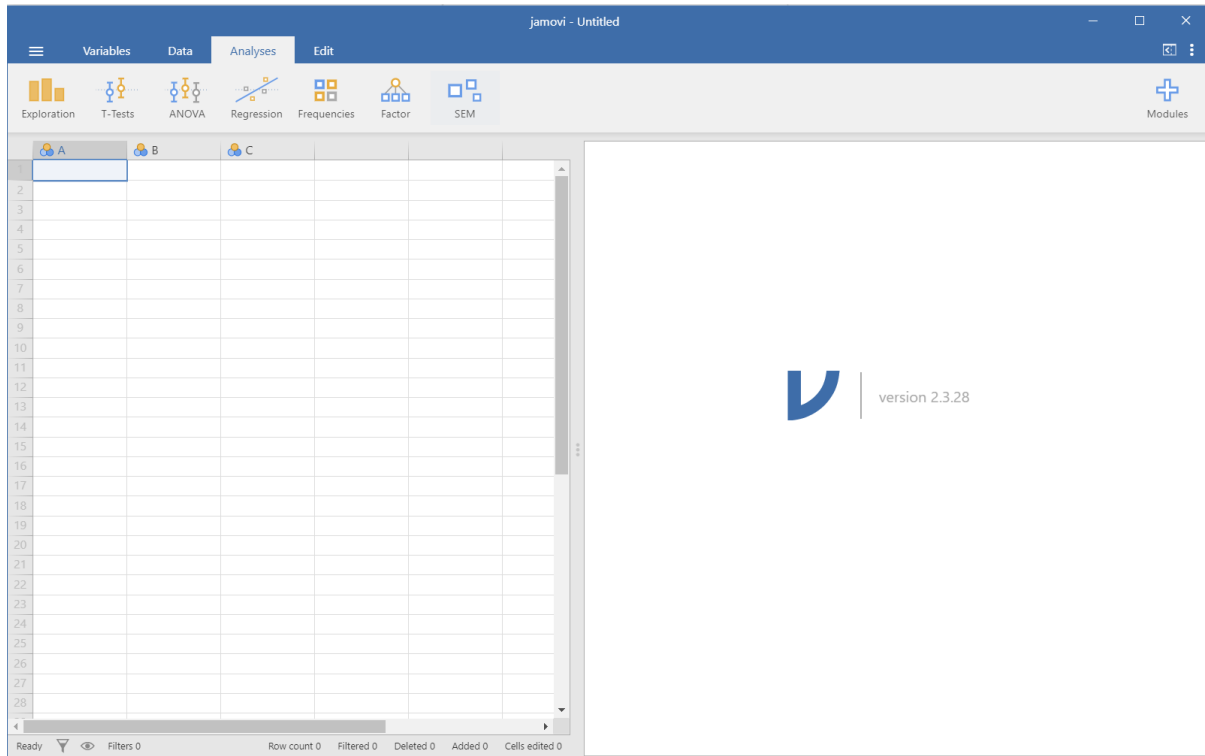
7. On the right, the contingency table is visible. Notice that the software automatically calculates N value, degree of freedom, and χ^2 value and shows p-value.

Appendix J.2

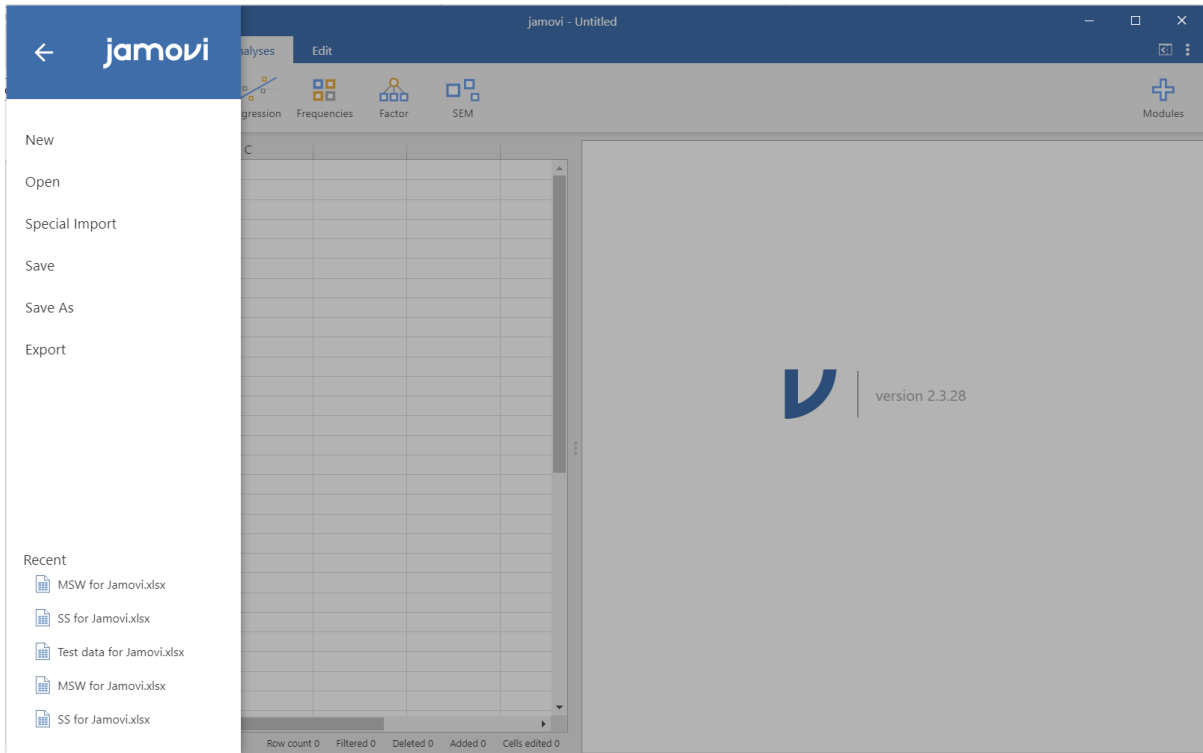
Steps taken in Jamovi for calculation of SEM results

The software “Jamovi” (version 2.2.5) was used to conduct structural equation modelling. Here are the steps followed.

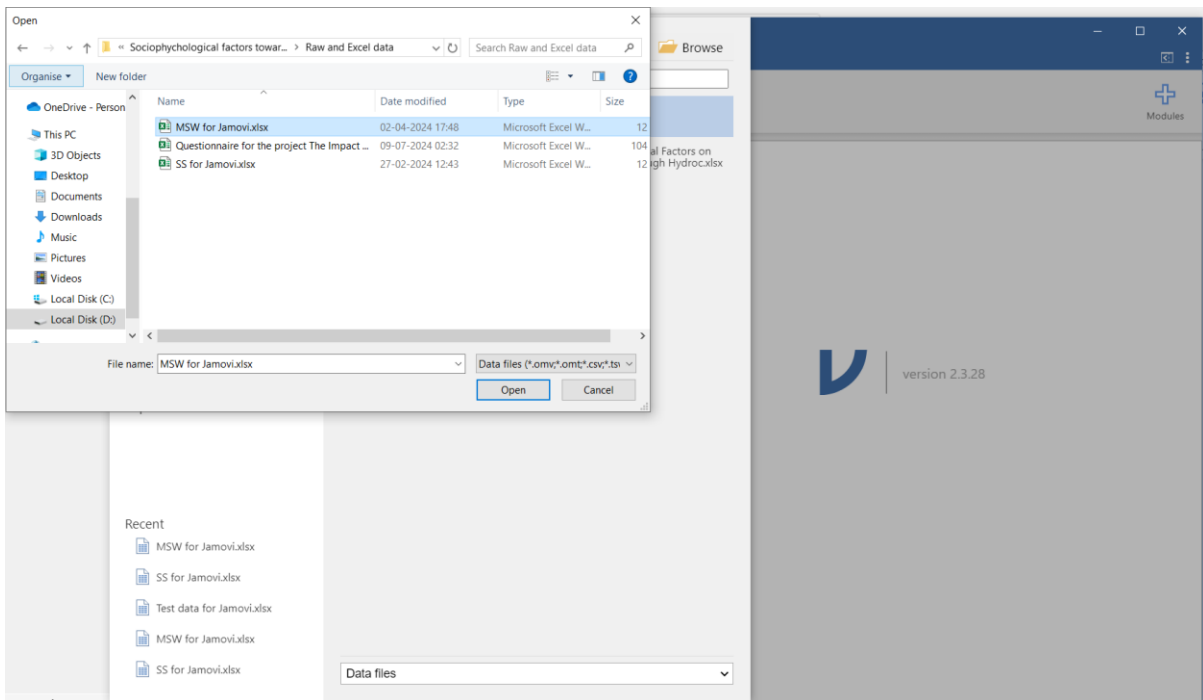
1. Open Jamovi software, the following screen is shown.



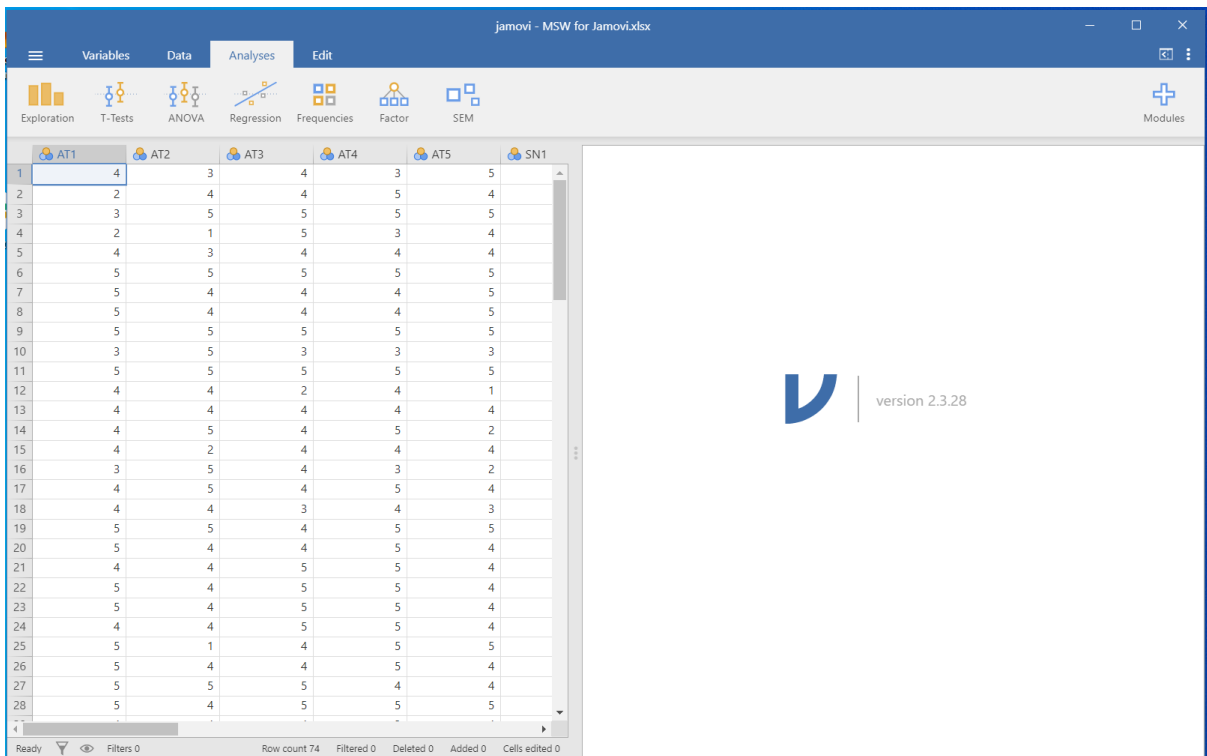
2. Click on the three lines in the top left corner, and select “open” to open your data.



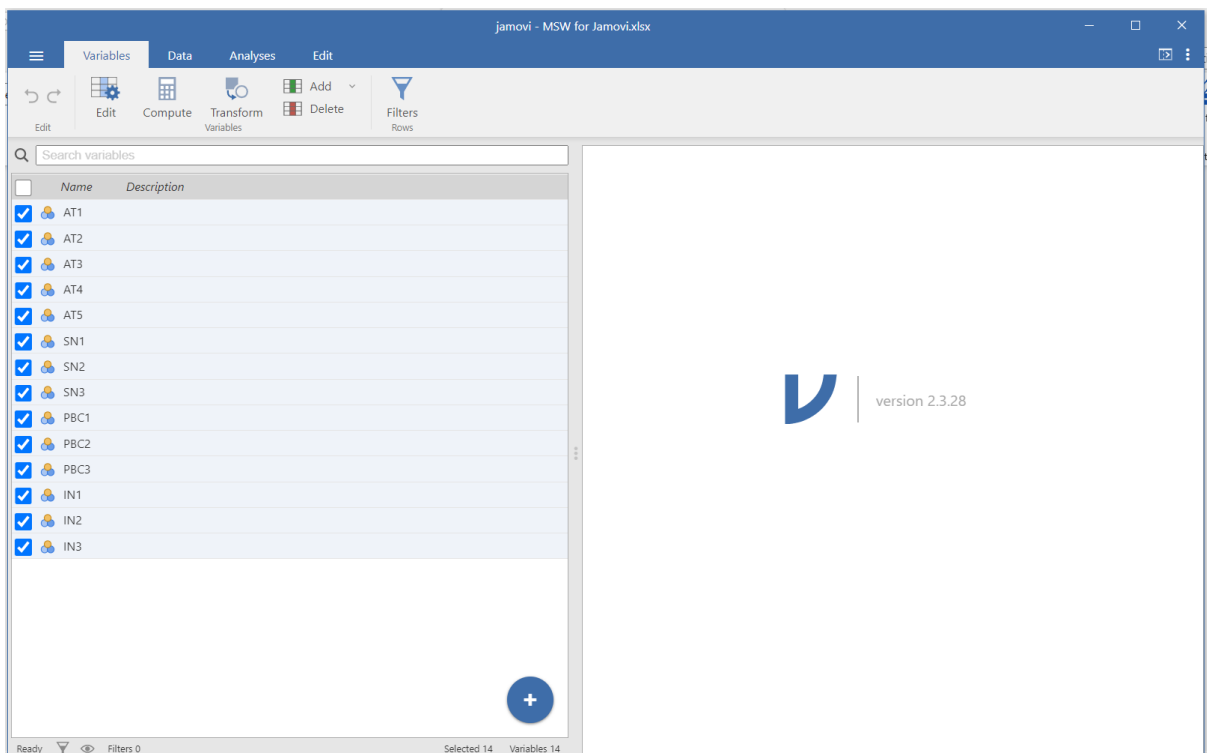
3. Click on “Browse”, and locate and select the Excel file which contains your data.



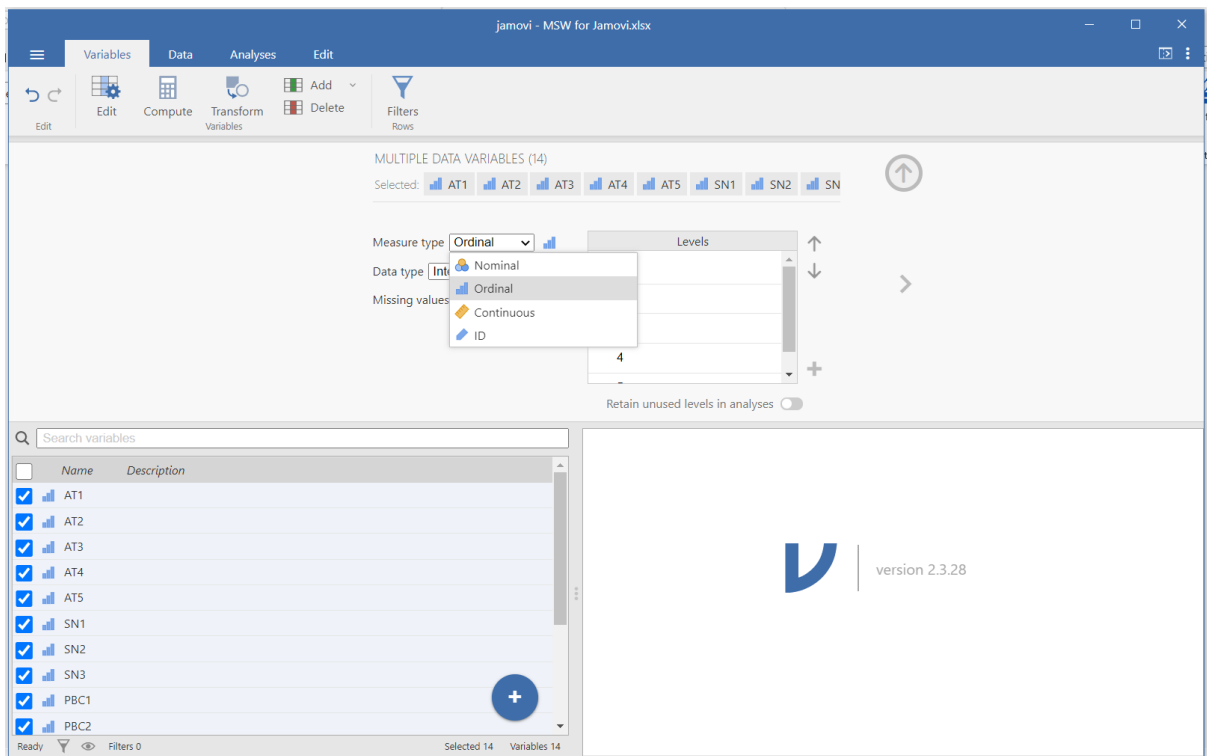
4. Click on “Open”. You will see the following screen. Notice that the question types (AT1, AT2, AT3...) have automatically become column headings.



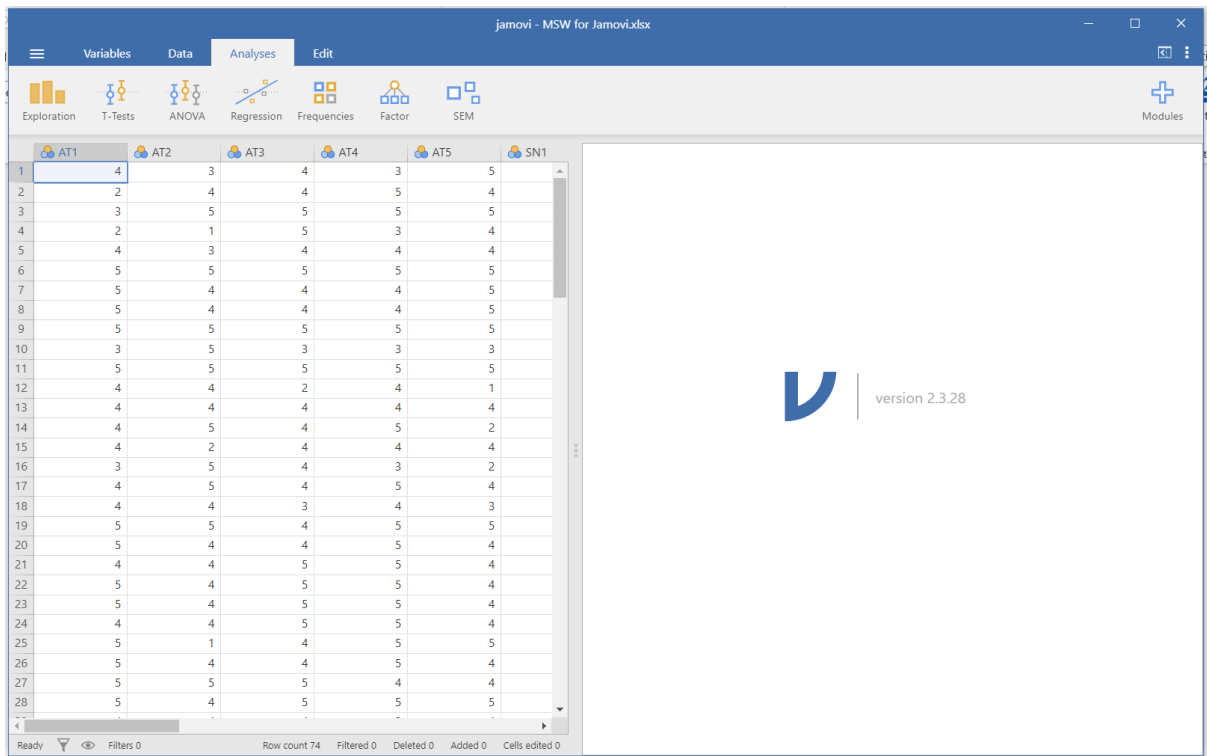
5. First, we need to confirm that our data follows ordinality and is of integer type. Click on the Variables tab, select each variable (AT1, AT2, AT3, ..., IN3).



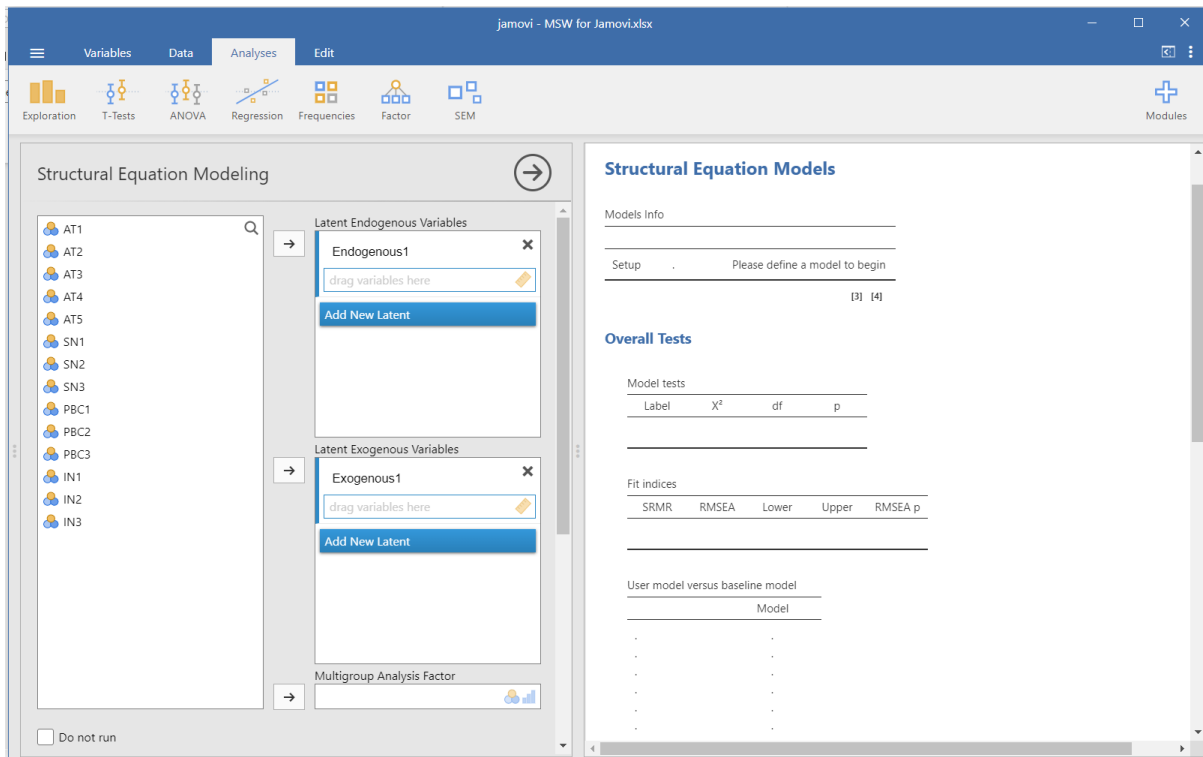
6. click on “Edit”. Select measure type as Ordinal, and Data type as Integer. It is important to define our data or else it might give us wrong results.



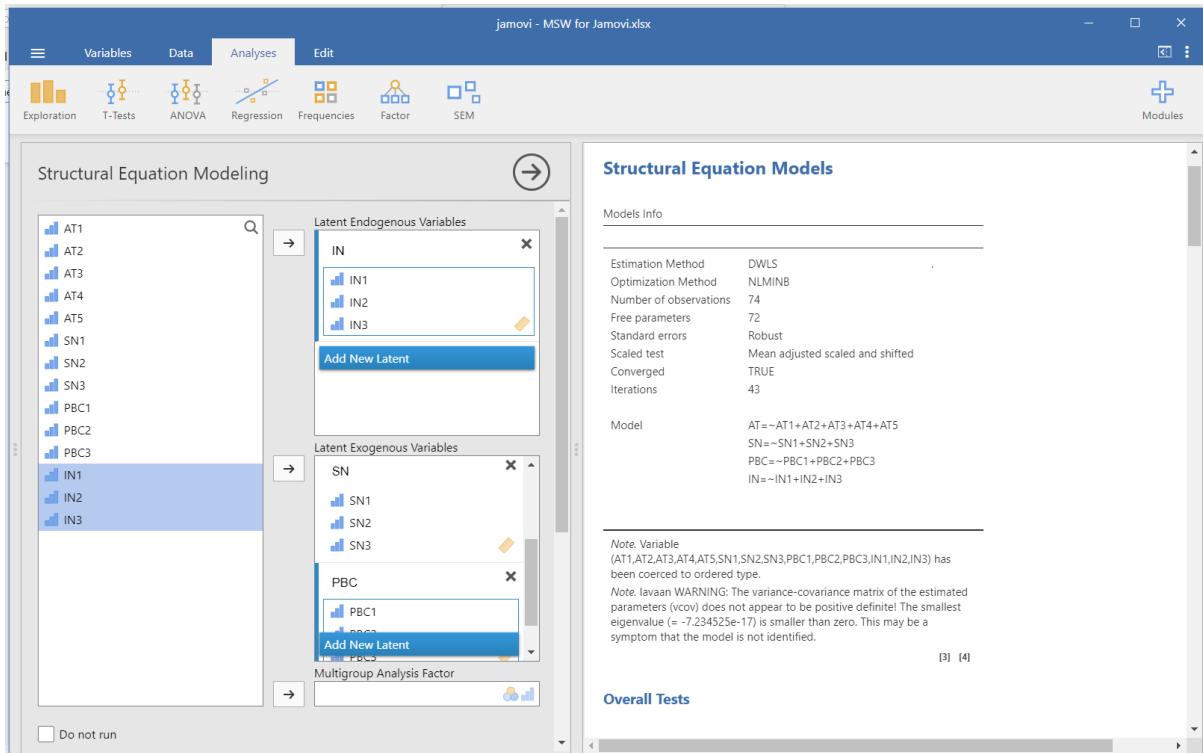
7. Now click on “Analysis” tab because now we can start analysing our data. Click on “SEM”. It is expected that the SEM package is already installed in your Jamovi library, or else download it using the plus sign named modules on the top right corner. When you click on SEM, select “SEM (interactive)”.



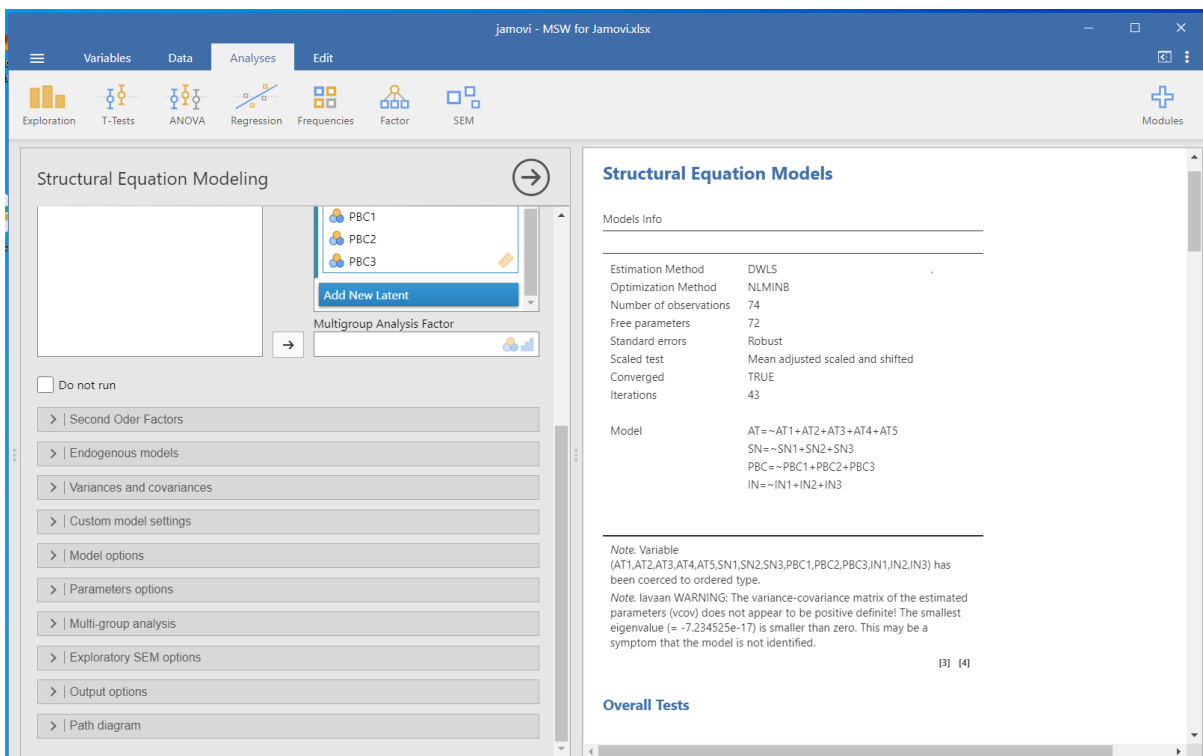
8. The following screen will appear.



9. Please select your latent endogenous variables and latent exogenous variables. You may rename the terms Endogenous1, Exogenous1, and add more Exogenous latent. It is to be noted that AT, SN, and PBC are exogenous latent because in our hypothesis they are not dependent on each other. However, IN should be endogenous because as per our hypothesis, IN is getting affected by AT, SN, and PBC.



10. Scroll down the left screen and select open the path diagram.



11. Tick on the Path diagram box so that you can see the path diagram on the right screen. The user might have to scroll down to see the path diagram. The user can also access all the parameters of the model on the right sheet.

jamovi - MSW for Jamovi.xlsx

Variables Data Analyses Edit

Exploration T-Tests ANOVA Regression Frequencies Factor SEM

Structural Equation Modeling

- Endogenous models
- Variations and covariances
- Custom model settings
- Model options
- Parameters options
- Multi-group analysis
- Exploratory SEM options
- Output options
- Path diagram

Path diagram **Path diagram**

show residuals show intercepts

Paths

- Coefficients
- Betas
- Labels
- None

Layout

Type: Tree-like

Rotate: Exog. left

Nodes

Node Size: Medium

Manifest shapes: Rectangles

Latent shapes: Circles

Abbreviate: 5

Structural Equation Models

Models Info

Estimation Method	DWLS
Optimization Method	NLMINB
Number of observations	74
Free parameters	72
Standard errors	Robust
Scaled test	Mean adjusted scaled and shifted
Converged	TRUE
Iterations	43

Model

$$AT = -AT1 + AT2 + AT3 + AT4 + AT5$$

$$SN = -SN1 + SN2 + SN3$$

$$PBC = -PBC1 + PBC2 + PBC3$$

$$IN = -IN1 + IN2 + IN3$$

Note. Variable (AT1,AT2,AT3,AT4,AT5,SN1,SN2,SN3,PBC1,PBC2,PBC3,IN1,IN2,IN3) has been coerced to ordered type.

Note. lavaan WARNING: The variance-covariance matrix of the estimated parameters (vcov) does not appear to be positive definite! The smallest eigenvalue (= -7.234525e-17) is smaller than zero. This may be a symptom that the model is not identified.

[3] [4]

Overall Tests

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Variables Data Analyses Edit

Exploration T-Tests ANOVA Regression Frequencies Factor SEM

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Path diagrams