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Multifunctional Porous Pavement Prototype for Urban Pluvial Flood Protection: Preliminarily Findings on Contribution of Attitudes to Acceptance Willingness Toward Proposed Scientific and Engineering Solutions

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Abstract

Rapid urbanization and climate change correlate with an increase in frequency of flood events, globally. For many cities worldwide pluvial floods bring significant risk. Permeable/pervious paving (PePav), as an essential sustainable urban drainage technique, is one of the key environmental solutions for urban flooding. Waste and recycled materials in the construction industry for PePav production comply with the principles of circular economy and sustainable development. The influence of the human factor is well recognized in efforts to apply those solutions and make them self-sustainable. The preliminary results show that younger female students and students with lower family monthly income are prone to express more positive attitudes toward PePav generally. Students from different study groups (Departments of Psychology, Hydraulic and Environmental Engineering, and Construction Project Management) show significantly different attitudes toward PePav. Statistical models indicate that the PePav acceptance willingness can be predicted with moderate accuracy by knowing attitudes toward PePav and personal experience in construction. The contributions of the fact that someone's close person has been affected by a flood may vary depending on the type of PePav scientific and engineering solutions.

1. Introduction

It is estimated that by 2050 over 70% of the overall world population will live in urban areas [1]. This is understandable and expected since the world population rapid grow and the provision of safe shelter is one of the basic human needs and rights [2].

Still, the process of urbanization like any other civilization's legacies has advantages and disadvantages. According to Chen et al. [3], "Urbanization is a double-edged sword". In response to rapid urbanization and climate change, over the past few decades, increasing frequency of flood events has been observed, globally [4],

[5]. Among them, pluvial floods have been seen as a major threat that brings a significant risk to many cities worldwide [6].

In line with that, urban stormwater management and low-impact development have become hotspots in research and practice [7], [8]. The main goal of scientific efforts is to provide environmental solutions for urban flooding [9]. Permeable/pervious paving (PePav), as an essential sustainable urban drainage (SUDS) technique, is one of those solutions. PePav may reduce the runoff volumes and rates, and simultaneously improve the stormwater quality [7].

Waste and recycled materials (WRM) in the construction industry for PePav production comply with the principles of circular economy and sustainable development [10]-[12].

In an era of the self-sustainable and interdisciplinary approach, one of the questions that arose is – what would be the impact of the human factor in PePav solution implementation? Or, how the knowledge of psychological factors can contribute to this matter? This paper will present the basic research insights on relationships between socio-demographic variables, relevant experience (in recycling, construction, and flooding), and PePav methodology *attitudes* and *acceptance willingness*, along with recommendations for further research.

1.1 Concerns

Urbanization means economic and social progress [13], better educational opportunities [14], and easier access to health services [3]. Nevertheless, urbanization progress has "its price". One of the major disadvantages is possible environmental degradation by an expansion of built-up area [15]. For example, the area of impervious surfaces has grown which leads to the reduction of infiltration during storm events. It has a significant contribution to the augmentation of direct stormwater runoff [16]-[18] and pluvial flooding occurrence [19] [20]. That became a major challenge for urban ecological safety [21].

In Serbia, in many cities, urban flooding occurs on an almost annual basis [7], [22]. Besides climate change influences those heavy rainfall events is highly related to traditional urban drainage practice (mainly focus on conveyance and partial retention of stormwater) [7]. Flooding generally accounts for nearly half of all-natural disasters and causes about half of all deaths worldwide [23], [24]. Floods may lead to economic losses of approximately 185 billion USD in just one decade [25].

In Serbia, after Cyclone Tamara, heavy rainfall caused large-scale floods in many urban and rural settlements [26], with estimated material damage of up to 1.7 billion euros [27], [28]. At least 57 people lost their lives [29]. Multiple communicable (CDs) and non-communicable (NCDs) diseases can be linked to flooding [30]-[35]. Psychological problems may occur or last for a long time after the water has receded and can lead to a significant diminution in the population's well-being [23].

1.2 Permeable/Pervious Paving as A Sustainable Urban Drainage Technique

The Zero Waste Water For Flood-Resilient Cities (Ø-Waste-Water) is an interdisciplinary project which engaged advanced and innovative strategies that propose SUD measures to improve urban flood management in Serbia [36]. The global main scientific and engineering objective is to develop a multifunctional porous pavement prototype (PPP) for simultaneous surface runoff reduction, urban flood protection, and pollutant removal. One of the specific objects is to select and investigate different kinds of municipal and industrial wastes, generated in Serbia, suitable for PePav production such as blast furnace slag from steel and copper production, fly ash, solidified wastewater treatment sludge, cathode ray tube glass, etc. Govedarica et al. [7] already examined the potential of solidified wastewater treatment sludge as a supplementary cementitious material in the production of lightweight pervious concrete pavers suitable for pedestrian trails and rooftops (green) that comply with EU standards.

Apart from the previously mentioned materials suitable for PePav production, one of the possibilities is harmless material, which has a useful value, and is called *neutral*" [37]. It is obtained by MID-MIX® patented and protected technology, which treats the most diverse types of hazardous industrial waste (old oils and industrial residues, soil contaminated with organic waste, petrochemical and pharmaceutical residues, various industrial and municipal sludge, paints and varnishes, tar and phenols, paraffin residue, separator filter waste, galvanic sludge, emulsions, solvents, sludge from wastewater plants and fly ash) [38]-[39] and turn it into a harmless "*neutral*" [37]. The research team from the Faculty of Technical Sciences in Novi Sad, headed by Bojana Zoraja, also dealt with the possibilities of treating asbestos waste with the MID-MIX® technology [39].

The acceptance of PePav solutions is inextricably linked with and determined by the construction waste management (CWM) concept.

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1.3 Proposed Pluvial Flooding Reduction Solutions and Human Factor

The synergistic approach of Ø-Waste-Water project expert team and joined research activities imply, among other things, understanding the influence of human factors in applying and facilitating project ideas, especially in terms of project self-sustainability. Human factors additionally gain importance when the multiple empirically confirmed connections between floods, and public health [5], [12[, [40]-[44] and wellbeing [45], [46] is taken into account.

Two broad groups of human factors must be considered: *personal* and *social* [47]. As for *personal factors*, knowledge, motivation, beliefs, attitudes, and behaviour stand out as especially important research concepts for the practice of CWM [47]. When it comes to attitudes, it has been shown that negative attitudes toward waste reduction have become one of the main reasons for the difficulties in waste management in the construction industry [48]. Therefore, decision-makers must adequately consider not only the technical aspects and costs of implementing new scientific and technological solutions but also the residents' attitudes [49].

If the goal is a successful and self-sustainable program, it is critical to address the s*ocial factors*, too. First, it means grasping relevant groups of stakeholders. In the case of the Ø-Waste-Water project, those are relevant members of the general population, construction workers, construction managers, and decision-makers. The interdisciplinary approaches between all the stakeholders are essential for successful waste management practices [50], especially the collective effort and the shared responsibility from the parties involved in CWM activities [47]. An additional reason for working with the general population or end users is the phenomenon of social influence. Namely, recyclers were more likely than non-recyclers to believe that friends, neighbours, and their local city council approved recycling [51]. Also, recyclers were more likely than non-recyclers to be motivated to comply with what their neighbours and local city council wanted them to do about recycling. Stakeholders want to know about technical aspects and implementation costs [49]. That information influenced the *willingness* of consumers to participate in recycling activities. That is why it is substantial to improve stakeholders' awareness of environmental and economic considerations of the project ideas [39], [52], [53].

But, there are no strict and unambiguous relations between those factors. Proper knowledge, adequate motivation, appropriate beliefs, and positive attitudes do not guarantee desired behaviour. For instance, positive attitudes toward waste management are influenced by social pressure [47]. Social pressure or norms may have the greatest impact where an individual exhibits a certain behaviour positively when he/she perceives that it is important what others think he/she should be doing. Besides that, if site operatives believe that they have little control over waste management performance, or that their contribution will not be valued, their behaviour will reflect these beliefs [54].

2. Method

2.1 Goal

The main goal of pilot research was to create the method and technique for the assessment of the *attitudes* and *willingness* of the stakeholders to accept the PePav, as well as the relevant influencing factors. The assessment performed concerning PePav based on (i) the Ø-Waste-Water project proposed solution ($PePav_{Ø\text{-}W\text{-}W}$), and (ii) *neutral* ($PePav_N$).

2.2 Sample

The preliminarily, a convenient sample, was consisted of 184 students:

- From the University of Belgrade, Serbia – 90 (48.9%) from the Department of Psychology Faculty of Philosophy (S_P) and 86 (46.8%) from the Faculty of Civil Engineering (66 (36.9%) from the Department of Hydraulic and Environmental Engineering (S_{HEE}) and 20 (10.9%) from the Department of Construction Project Management (S_{CPM}), and
- 8 (4.4%) students of the Faculty of Technology University of Novi Sad, Serbia (S_T).

The average age of students was 22.08 years (SD = 2.10). 60 (32.6%) were male, and 123 (66.8%) were female. 31 (16.8%) stated that they currently live alone, 112 (60.9%) with parents, 13 (7.1%) with a partner, 19 (10.3%) with a roommate, and 6 (3.3%) with siblings. Most students came from households with 3 to 5 members 153 (83.1%), and 17 (9.2%) from a household with two members. From single-member households, and those with 6 or more members, there were 7 (3.7%) per group. 42 (22.8%) respondents came from a household with one minor member, 8 (4.3%) with two minor members, while the remaining number of respondents 134 (72.8%) came from families where at the time of research, all members were already at legal age.

2.3 Instruments

2.3.1 A Structured Interview

A structured interview was developed for project purposes to obtain information about relevant socio-demographic variables (age, gender, educational level, occupation, family status, income, living area (rural/urban), professional experience, experience in construction, experience with hazardous water flooding, general recycling awareness and practice, availability of recycling amenities and general CWM policies perception).

2.3.2 PePav Project Proposed Solution and Neutral Rating Scales

The seventh-point semantic differential scales were created for the assessment of PePav based on (i) $PePav_{Ø\text{-}W\text{-}W}$ (PRS), and (ii) $PePav_N$ (NRS). Initially, scales consisted of 15 opposite adjectives, which were chosen from relevant research literature and interviews with stakeholders during the preparatory phase. After descriptive statistical analysis, it remained the 7 adjectives with the most robust statistical characteristics (*risky – safe, useless – useful, unimportant – important, impractical – practical, non-resistant – resistant, harmful – harmless, unnecessary – necessary*). Respondents were asked to rate each of the two types of PePav using a list of the same opposite adjectives. Research instruction according to PRS has included information that they contained industrial/fly ash, cathode ray tube glass, and blast furnace slag. Research instruction according to NRS has included information that they contained waste oils and emulsions, fuel oil, paints, fixers and developers, powders from metallurgical processes, oily and contaminated soil, and asbestos and asbestos products. Adjectives were rated by a 7-point Likert scale ranging from 1 (negative adjective values) to 7 (positive adjective values). Thus, for individual adjectives, the range of scores was 1-7, and for full scales 7-49. Lower scores indicated more negative attitudes or stricter evaluations of the PePav solutions. The reliability coefficient for the final, 7th item scales were $\alpha_{PRS} = 0.879$ and $\alpha_{NRS} = 0.921$.

2.3.3 Rating Scales for Willingness to Use the PePav Based on The Project Proposed Solution and Neutral

Bogardus' social distance scale was readapted to evaluate the *willingness* of respondents to apply PePav based on (i) $PePav_{Ø\text{-}W\text{-}W}$ (PWU), and (ii) $PePav_N$ (NWU). Respondents had the task of evaluating to what extent it would be acceptable for them to cover with one or with another type of PePav different types of surfaces/objects, with different social meanings, at different proximity. These surfaces/objects were: all streets and roads in populated areas, streets and roads in flooded areas, sidewalks and roads around hospitals and other health institutions, the area around children's playgrounds, the surroundings of the respondent's company/workplace, the street where the respondent lives, and the respondent's yard. An 8-point scale ranging from 1 ("not under any condition") to 8 ("yes, with no doubt") was used. The score ranges for single objects/surfaces and whole scales PWU and NWU was 1-8. For a single object/surface, lower scores mean lower respondent *willingness* to apply one or another solution to the mentioned object. On the whole scale, a lower score means that respondents are generally less ready to implement the PePav solution they were asked about. The obtained reliability coefficients were $\alpha_{PSWU} = 0.948$ and $\alpha_{NWU} = 0.965$.

2.4 Data Analysis

Statistical analysis was performed with the statistical package SPSS, version 23. The assessment of central tendency, variability, and frequency distributions was conducted by descriptive statistical analysis. The effects of relevant variables (socio-demographic variables, experience with flooding and recycling) on recycling attitudes to PePav solutions are investigated through correlation analysis, independent Samples t-Test, and one-way ANOVA. To explain the relationship between *willingness* to accept those solutions and socio-demographic variables, experience (with flooding, construction/adaptation and recycling), and PePav attitudes, multiple linear regression was used.

3. Results

The first question was whether the type of material which will be used for PePav ($PePav_{Ø\text{-}W\text{-}W}$ or $PePav_N$) led to differences in the respondents' attitudes toward PePav (Table 1 and Table 2).

Significant differences were obtained for the scales as a whole ($M_p = 39.30$, $AS_p = 6.88$, $M_n = 38.62$, $AS_n = 7.53$, $t(166) = 2.09$, $p = 0.038$), and the ratings of the two mentioned technologies in terms of their *usability* ($M_p = 5.99$, $AS_p = 1.27$, $M_n = 5.68$, $AS_n = 1.27$, $t(171) = 3.48$, $p = 0.001$), *resistance* ($M_p = 4.93$, $AS_p = 1.29$, $M_n = 5.16$, $AS_n = -1.33$, $t(169) = 2.40$, $p = 0.018$), *harmlessness* ($M_p = 5.77$, $AS_p = 1.23$, $M_n = 5.56$, $AS_n = 1.41$, $t(170) = 2.43$, $p = 0.016$) and *necessity* ($M_p = 5.89$, $AS_p = 1.27$, $M_n = 5.71$, $AS_n = 1.32$, $t(171) = 2.31$, $p = 0.022$). The differences are such that the

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respondents systematically rated $PePav_N$ as less *useful* and less *necessary*, and more *harmful*, even though they experienced them as more *resistant*. When we look at the scale as a whole, respondents expressed generally more negative attitudes towards $PePav_N$ concerning $PePav_{Ø\text{-}W\text{-}W}$.

Table 1 *Descriptive statistics for age, monthly income of the family, and PRS and NRS variables*

	N	Min.	Max.	M	SD	Skewness	Kurtosis
age	184	19.00	29.00	22.08	2.10	1.56	2.27
monthly income*	99	10.000	170.000	53.168,96	30.831,16	0.98	1.23
$safeness_p$	179	1.00	7.00	5.26	1.25	-0.73	0.58
$usability_p$	177	1.00	7.00	5.99	1.27	-1.49	2.26
$importancy_p$	177	1.00	7.00	5.80	1.32	-1.24	1.56
$practicality_p$	177	1.00	7.00	5.62	1.37	-0.86	0.52
$resistance_p$	174	1.00	7.00	4.93	1.29	-0.44	0.09
$harmlessness_p$	175	1.00	7.00	5.77	1.23	-1.06	0.98
$necessity_p$	175	1.00	7.00	5.89	1.27	-1.20	1.49
PRS	173	12.00	49.00	39.30	6.88	-1.06	1.70
$safeness_n$	173	1.00	7.00	5.19	1.32	-0.49	-0.14
$usability_n$	174	1.00	7.00	5.68	1.27	-1.01	1.06
$importancy_n$	174	1.00	7.00	5.71	1.22	-0.96	0.89
$practicality_n$	174	1.00	7.00	5.52	1.29	-0.79	0.54
$resistance_n$	172	1.00	7.00	5.16	1.33	-0.72	0.53
$harmlessness_n$	172	1.00	7.00	5.56	1.41	-1.05	0.87
$necessity_n$	173	1.00	7.00	5.71	1.32	-1.30	2.16
NRS	170	10.00	49.00	38.62	7.53	-0.94	1.21

* in local currency (RSD)

Table 2 *Paired sample t-test results for PRS and NRS*

	M	SD	SE_M	95% Confidence Interval		t	df	p[a]
				Lower	Upper			
PRS-NRS	0.86	5.28	0.41	0.05	1.66	2.09	166	0.038
$safeness_p$-$safeness_n$	0.10	1.45	0.11	-0.11	0.32	0.94	172	0.347
$usability_p$-$usability_n$	0.34	1.27	0.10	0.15	0.53	3.48	171	0.001
$importancy_p$-$importancy_n$	0.13	1.21	0.09	-0.05	0.31	1.38	172	0.170
$practicality_p$-$practicality_n$	0.14	1.28	0.10	-0.05	0.33	1.42	172	0.156
$resistance_p$-$resistance_n$	-0.24	1.28	0.10	-0.43	-0.04	-2.40	169	0.018
$harmlessness_p$-$harmlessness_n$	0.25	1.35	0.10	0.05	0.46	2.43	170	0.016
$necessity_p$-$necessity_n$	0.22	1.22	0.09	0.03	0.40	2.31	171	0.022

[a]2-tailed; SE_M – standard error of mean; p - Ø-Waste-Water project proposed solution; $_n$ - *neutral*

The second question was about the relationship between numerical variables (gender and age), single items from rating scales, and rating scales as a whole.

Table 3 *Intercorrelation matrix of gender, age, PRS items, and whole PRS*

	1	2	3	4	5	6	7	8	9	10
1. age	—									
2. monthly income	0 .20*	—								
3. $safeness_p$	-0.24**	-0.09	—							
4. $usability_p$	-0.09	-0.24*	0.36**	—						
5. $importancy_p$	-0.11	-0.15	0.31**	0.73**	—					
6. $practicality_p$	-0.11	-0.11	0.36**	0.63**	0.74**	—				
7. $resistance_p$	-0.15	0.02	0.27**	0.31**	0.39**	0.41**	—			
8. $harmlessness_p$	-0.16*	-0.03	0.41**	0.57**	0.61**	0.58**	0.51**	—		
9. $necessity_p$	-0.06	-0.14	0.38**	0.65**	0.71**	0.64**	0.39**	0.71**	—	
10. PRS	-0.18*	-0.13	0.47**	0.68**	0.62**	0.63*	0.51**	0.58**	0.63**	—

* Correlation is significant at the 0.05 level (2-tailed)
** Correlation is significant at the 0.01 level (2-tailed)

The age of the respondents shows low negative correlations with the ratings of $PePav_{Ø\text{-}W\text{-}W}$ as *safe* (r(179) = -0.24, p = 0.001), *harmless* (r(175) = -0.16, p = 0.040) and the scale as a whole (r(173) = -0.18, p = 0.021). The

correlation is such that the older the respondents are, the more they tend to rate this technology more strictly. The monthly income of the family shows a significant low correlation only with the rating of PePav as *useful* (r(97) = -0.24, p = 0.020). The correlation is such that the lower the family's monthly income, the more *useful* the respondents rate this technology. As expected, the individual opposing attributes correlate significantly, and positively - both with each other and with the whole scale.

Table 4 *Intercorrelation matrix of gender, age, NRS items and whole NRS*

	1	2	3	4	5	6	7	8	9	10
1. age	—									
2. monthly income	0.20*	—								
3. safeness$_n$	-0.15	-0.14	—							
4. usability$_n$	-0.15	-0.06	0.52**	—						
5. importancy$_n$	-0.08	0.02	0.45**	0.74**	—					
6. practicality$_n$	-0.15*	0.01	0.45**	0.72**	0.72**	—				
7. resistance$_n$	-0.14	0.13	0.38**	0.44**	0.55**	0.56**	—			
8. harmlessness$_n$	-0.17*	-0.01	0.66**	0.71**	0.70**	0.68**	0.61**	—		
9. necessity$_n$	-0.08	-0.03	0.56**	0.76**	0.77**	0.73**	0.59**	0.79**	—	
10. NRS	-0.16*	-0.02	0.71**	0.85**	0.85**	0.84**	0.72**	0.89**	0.90**	—

* Correlation is significant at the 0.05 level (2-tailed)
** Correlation is significant at the 0.01 level (2-tailed)

The age of the respondents has low negative correlations with the ratings of PePav$_N$ as *harmless* (r(172) = -0.17, p = 0.025), *practical* (r(174) = -0.15, p = 0.044), and the scale as a whole (r(170) = -0.16, p = 0.033). The correlation is such that the older the respondents are, the more they tend to rate this technology more strictly. As expected, individual opposing attributes correlate significantly, and positively - both with each other and with the entire scale, with the fact that in the case of PePav$_N$, the highest correlations were obtained between individual opposing attributes with the scale as a whole.

The t-test for independent samples was used to test the significance of the difference between the evaluations of the solutions provided by the project for PePav and PePav$_N$.

Table 5 *Independent sample t-test results related to gender comparison of PRS and NRS scores*

	male		female		t-test	df	p
	M	SD	M	SD			
PRS	37.93	6.02	39.96	7.18	-1.83	171	0.069
NRS	36.57	6.58	39.63	7.79	-2.49	167	0.014

Female respondents (M = 39.63, SD = 7.79), compared to male respondents (M = 36.57, SD = 6.58), rated PePav$_N$ with significantly higher scores (t(167) = -2.49, p = 0.014), but not the PePav solutions foreseen by the project (t(171) = -1.83, p = 0.069).

Table 6 *Independent sample t-tests related to comparison of PRS and NRS scores depending on relevant experience (in recycling, environmental activism, adaptation, construction, and flooding events (personal and close persons)*

	no		yes		t-test	df	p
	M	SD	M	SD			
recycling experience$_p$	37.49	7.98	40.19	6.10	-2.25	89	0.027
recycling experience$_n$	37.62	7.96	39.10	7.30	-1.21	168	0.230
environmental activism$_p$	40.21	5.72	38.86	7.35	1.21	171	0.228
environmental activism$_n$	39.21	7.30	38.33	7.65	0.72	168	0.475
adaptation experience$_p$	39.43	7.32	39.23	6.65	0.18	171	0.860
adaptation experience$_n$	38.53	8.80	38.68	6.74	-0.12	168	0.905
construction experience$_p$	39.33	7.04	39.10	5.67	0.15	171	0.884
construction experience$_n$	38.51	7.64	39.70	6.83	-0.66	167	0.509
personal flooding experience$_p$	39.21	6.76	39.48	7.31	-0.23	170	0.820
personal flooding experience$_n$	38.36	7.24	39.23	8.39	-0.66	167	0.513
close persons flooding experience$_p$	38.25	7.30	40.27	6.34	-1.94	171	0.054
close persons flooding experience$_n$	37.72	7.62	39.45	7.39	-1.51	168	0.134

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The respondents with experience in recycling (M = 40.19, SD = 6.10), in comparison to those without experience (M = 37.49, SD = 7.98), rate significantly higher $PePav_{Ø\text{-}W\text{-}W}$ (t(89) = -2.25, p = 0.027), but not $PePav_N$ (t(168) = -1.21, p = 0.230).

The differences in PePav scores of respondents whose close person was affected by a flood (M = 40.27, SD = 6.34), compared to those without such experience (M = 38.25, SD = 7.30), were at the border of statistical significance (t(171) = -1.94, p = 0.054). The differences were not statistically significant for $PePav_N$ (t(167) = -1.51, p = 0.134).

For the remaining variables (participation in environmental protection activities, participation in space adaptation, personal experience with floods), no significant differences were found either for the evaluation of $PePav_{Ø\text{-}W\text{-}W}$ or for $PePav_N$.

To examine the relative contribution of socio-demographic variables, relevant past experience, and attitudes towards PePav in assessing *willingness* to accept PePav solutions, four linear regression models were tested – two with PWU and two with NWU as a criterion.

The following variables are included as predictors: gender, age, monthly family income, existing experience with recycling, participation in environmental protection activities, experience in remodelling the space where they live or work, experience in building a residential unit or business space for oneself, personal experience with the flood, the circumstance that a person close to the respondent was affected by the flood and *attitudes* towards the type of PePav material (PRS in first and third model, NRS in second and fourth).

Namely, since monthly income did not prove to be a significant predictor, despite the previously established association with one of the opposing attributes for PS, and led to the exclusion of 50% of the sample from the analysis due to missing responses, this variable was excluded from the 3rd and 4th model. The variable monthly family income is an otherwise complex research problem within local cultural peculiarities. The amount of material income is perceived as an element of privacy. The sensitivity of this information is also indicated by the fact that in this survey, almost 50% of respondents chose not to answer this question.

Table 7 *Model summary and coefficients of each linear regression model*

Model	Criteria	R^2	F	df1	df2	p
1	PWU	0.352	4.950	9	82	<0.001
2	NWU	0.277	3.442	9	81	0.001
3	PWU	0.278	7.597	8	158	<0.001
4	NWU	0.337	9.770	8	154	<0.001

The third tested model suggests that the factors included in the model explained 27.8% of the variance of the criterion (PWU) and that this model is statistically significant (p <0.001). Among the tested predictors, *attitudes* towards $PePav_{Ø\text{-}W\text{-}W}$ (β = 0.348, p < 0.001), the fact that a person close to the respondent was affected by a flood (β = 0.173, p = 0.019) and previous construction experience (β = -0.164, p = 0.024) have a statistically significant relative predictive contribution. The direction of the relationship indicates that more positive attitudes towards this solution and the fact that a close person was affected by the flood lead to a greater *willingness* of respondents to accept it. On the other hand, having experience in the field of building a residential unit or commercial space for yourself leads to greater restraint. Respondents' gender (β = 0.140, p = 0.060) and age (β = -0.067, p = 0.369), experience with recycling (β = 0.202, p = 0.050), participation in environmental protection and improvement activities (β = -0.083, p = 0.428), experience in remodelling the space where the respondents live or work (β = - 0.051, p = 0.608), and personal experience with a flood (β = 0.058, p = 0.592) did not reach the level of statistical significance.

The fourth tested model suggests that the factors included in the model explained 330.8% of the variance of the criterion (NWU) and that this model is statistically significant (p<0.001). Among the included predictors, *attitudes* towards $PePav_N$ (β = 0.443, p < 0.001) and previous construction experience (β = -0.175, p = 0.014) have a statistically significant relative predictive contribution. The direction of the relationship, as in the case of $PePav_{Ø\text{-}W\text{-}W}$, indicates that more positive *attitudes* towards this solution lead to a higher, and having experience in the field of construction, a lower *willingness* of respondents to accept it. Under this model, the circumstance that a person close to the respondent was affected by a flood is on the borderline of significance in terms of predictive contribution (β = 0.280, p = 0.053). Existing experience with recycling (β = 0.088, p = 0.219), participation in environmental protection and improvement activities (β = 0.035, p = 0.624), experience in remodelling the space where respondents live or work (β =-0.072, p = 0.294) and personal experience with a flood (β = 0.041, p = 0.550) did not reach the level of statistical significance.

In the end, it seemed important to determine whether, and in what way, student grades differ depending on the types of PePav included in this research ($PePav_{Ø\text{-}W\text{-}W}$ and $PePav_N$). In concordance with the chosen statistical test preconditions, analyses have included students of three departments: the Departments of Psychology (S_P),

the Department of Hydraulic and environmental engineering (S_{HEE}), and the Department of Construction project management (S_{CPM}).

Post hoc comparisons using the Tukey HSD test indicated that, concerning PRS (Table 8), in S_P the mean scores for most of the opposite attributes, except *resistance*, were significantly higher than in S_{HEE}. Taken together, these results indicate that S_{HEE} more stringent assessed $PePav_{ø\text{-}w\text{-}w}$. S_{CPM} ratings did not significantly differ either from S_P or S_{HEE}.

Table 8 *Result of Tukey posthoc test for PRS items and whole scale between S_P, S_{HEE}, and S_{CPM}*

	S_P	S_{HEE}	S_{CPM}
	M(SD)	M(SD)	M(SD)
$safeness_p$	5.51(1.14)*	4.94(1.39)*	5.32(1.06)
$usability_p$	6.36(1.05)*	5.60(1.43)*	5.74(1.19)
$importancy_p$	6.10(1.15)*	5.41(1.42)*	5.78(1.40)
$practicality_p$	5.84(1.29)*	5.23(1.43)*	6.06(1.16)
$resistance_p$	5.09(1.28)	4.71(1.30)	5.06(1.34)
$harmlessness_p$	6.06(1.14)*	5.38(1.34)*	5.94(0.75)
$necessity_p$	6.18(1.13)*	5.56(1.41)*	5.76(0.97)
PRS	41.11(6.07)*	36.89(7.38)*	39.94(5.25)

* The mean difference is significant at the 0.05 level.

Post hoc comparisons using the Tukey HSD test indicated that concerning $PePav_N$ (Table 8), a different picture is obtained. In S_P only the mean scores for *safeness*, *usability*, and *necessity* were significantly higher than in S_{HEE}. S_P ratings concerning the other 5 opposite attributes, and total scale, did not significantly differ neither from S_{HEE} or S_{CPM}.

Table 9 *Result of Tukey posthoc test for NRS items and whole scale between S_P, S_{HEE}, and S_{CPM}*

	S_P	S_{HEE}	S_{CPM}
	M(SD)	M(SD)	M(SD)
$safeness_n$	5.38(1.38)*	4.82(1.23)*	5.35(1.17)
$usability_n$	5.92(1.38)*	5.37(1.10)*	5.71(1.10)
$importancy_n$	5.85(1.27)	5.44(1.13)	5.94(1.14)
$practicality_n$	5.62(1.41)	5.31(1.12)	5.71(1.16)
$resistance_n$	5.13(1.40)	4.93(1.26)*	6.00(0.87)*
$harmlessness_n$	5.70(1.50)	5.15(1.34)*	6.19(0.66)*
$necessity_n$	6.00(1.31)*	5.30(1.32)*	5.65(1.06)
NRS	39.63(7.91)	36.53(6.99)	40.56(5.66)

* The mean difference is significant at the 0.05 level.

In the case of $PePav_N$, a significant difference has occurred between two groups of Civil engineering students. Thus, in S_{HEE} the mean scores for *harmlessness* and *resistance* were significantly *lower* than in S_{CPM}. S_{CPM} ratings concerning the other 5 opposite attributes, and total scale, did not significantly differ either from S_P or S_{HEE}. Taken together, these results indicate that S_{HEE} more stringently assessed some of the $PePav_N$ attributes, both to S_P and S_{CPM}.

4. Discussion

Regarding *attitudes* on two types of PePav, at the scale as a whole respondents expressed generally more negative *attitudes* towards $PePav_N$ concerning $PePav_{ø\text{-}w\text{-}w}$. $PePav_{ø\text{-}w\text{-}w}$ has been seen as more *useful*, more *necessary*, and less *harmful*, even though the respondents perceived them as less *resistant*. Thus, potentially dangerous substances mention, even though the final product was certified as non-hazardous, led to significant differences in the respondents' *attitudes* towards these two technologies.

The older students in the sample have seen $PePav_{ø\text{-}w\text{-}w}$ as riskier, $PePav_N$ as more *impractical*, and both solutions as more *harmful*. Generally, the older the students were, the more they showed negative *attitudes* to both kinds of PePav technology. Similar findings came from studies with primary and secondary school students' sample regarding recycling behaviour [55], [56]. Contrary to that, many other studies reveal that older peoples have more positive attitudes toward recycling and are more likely to participate in recycling activities [57], [58]. It is important to bear in mind that this part of the research was conducted with university students. Research with wider age range samples indicates that there are curvilinear relationships – the trend toward using more

eco-products increases with age, but there is a dip in relation to the 26–35 age group [59]. Gender was also partially related to the type of PePav solutions in mean that female respondents expressed more positive *attitudes* to $PePav_N$. This is in line with research which shows that female students have more positive attitudes and participate more actively in recycling compared to their male peers [60]-[63]. For example, during research on recycling and waste management attitudes and behaviours, it was found that women were more concerned for environmental rather than cost reasons [59]. Students from families with lower monthly incomes have seen $PePav_{ø\text{-}W\text{-}W}$ as more *useful*. In some other research low income families also shows more positive attitudes and are more likely to be included in recycling behaviour [64], [65].

Students with experience in recycling, in comparison to those without experience, rated significantly higher the $PePav_{ø\text{-}W\text{-}W}$. It is an expected result, since the attitudes toward different kinds of recycling, and recycling behaviour in different contexts are empirically highly related [56], [59], [66]-[69].

Finding those students whose close person was affected by a flood, compared to those without such experience, has more positive *attitudes* to $PePav_{ø\text{-}W\text{-}W}$, is at the border of statistical significance. It seems that students with unfavourable, specific experiences were more open to project solutions, especially if the flood threatened someone close to the students (relatives or friends). The psychological literature, albeit not conclusive, strongly suggests the significance of a relationship between past flood experience and flood protective drivers. For example, in the case of property-level flood protection measures (PFLP), the research findings showed that the scale of flooding and impacts, as well as financial consequences, was linked to an increased importance recognition of PFLP, and an increased *willingness* to defray the cost of PLFP [49], [70].

Participation in environmental activities, experience in adaptation/construction, and personal experience with flooding events did not lead to the difference in the evaluation of either $PePav_{ø\text{-}W\text{-}W}$ or $PePav_N$.

Statistical models showed that both PePav *acceptance willingness* ($PePav_{ø\text{-}W\text{-}W}$ and $PePav_N$) can be predicted with moderate accuracy by knowing *attitudes* toward PePav and personal experience in construction. The fact that a close person was affected by the flood contribute significantly to the prediction of the $PePav_{ø\text{-}W\text{-}W}$ *acceptance willingness*, and for the $PePav_N$ this fact was on the borderline of significance. More positive attitudes towards both PePav solutions, and endangerment of close ones by the flood lead to a greater *willingness* of respondents to accept PePav. On contrary, having experience in the field of construction lead to a lower *willingness* of respondents to accept both PePav. Overall, as was expected, regression models showed the most highly relative contribution of *attitudes* in the prediction of *acceptance willingness* for both PePav solutions. Positive associations between *planned behaviour* (in this research presented by *acceptance willingness*) and positive attitudes toward environment/recycling are well documented [47]-[49], [57], [66], [71], [72]. Moreover, this part of the findings is in consistent with the results of relevant research on the relationship between experience and willingness to accept modern scientific and technological solutions. Namely, it has been shown that professional experience leads to less, and encounter with adversity to greater willingness to acquire some solution [49], [70].

Regarding the potential influence of educational specificities, the results show that S_{HEE}, in comparison with S_P and S_{CPM}, principally more stringent assessed the PePav solutions. Considering the $PePav_{ø\text{-}W\text{-}W}$, significant differences have occurred only between S_P and S_{HEE} students. *S_P* students were significantly favourably rated $PePav_{ø\text{-}W\text{-}W}$ on all opposite attributes, except on *resistance.* In the case of *$PePav_N$*, a significant difference appeared between all three groups of students. $S_{CPM,}$ compared to S_{HEE}, graded *$PePav_N$* as more *harmless* and more *resistant*. *S_P*, compared to S_{HEE}, have seen $PePav_N$ as *safer*, more *useful*, and more *necessary*. S_P and S_{CPM} grades did not differ for both PePav solutions. Some differences between the three groups of students were expected since it has been multiple confirmed that prior knowledge and experience are associated with attitudes and recycling activities [63], [71]. But, the directions of differentiations in some ways were opposite to what was anticipated. Namely, in relevant research sustainable waste management knowledge was positively associated with sustainable waste management attitudes and intentions [63], [68], [73]-[76]. On the ground of this research design, it is hard to explain the gained difference. Nevertheless, it is important to take them into account during the further research stages, as well as in the implementation of the project solutions and provision of the project interventions' self-sustainability.

One finding needs to be separately considered. It is the reticence of respondents when reporting on the monthly material income of the family. The importance of this variable for attitudes towards any phenomenon and related behaviour has been empirically confirmed multiple times, in various national and international studies. Therefore, it is important to consider how to reformulate the question/instructions, so that the respondents do not find it too intrusive. In any case, a face-to-face survey versus an online one seems like a much more viable way to get more credible answers.

5. Conclusions

Permeable/pervious paving (PePav), as an essential sustainable urban drainage technique, is one of the key environmental solutions for urban pluvial flooding. Waste and recycled materials in the construction industry for PePav produce comply with the principles of circular economy and sustainable development.

The influence of human factors is well recognized in efforts to apply those solutions and make them self-sustainable.

The preliminary results on the students' sample confirmed that the contribution of relevant past experience, and *attitudes* towards PePav has to be taken into account when peoples' *willingness to accept* PePav solutions is considered. Namely, older, and male students, and students with higher family monthly income are prone to express more negative *attitudes* toward PePav generally. Statistical models indicate that the PePav acceptance *willingness* can be predicted with moderate accuracy by knowing attitudes toward PePav and personal experience in construction. The contributions of the fact that someone's close person has been affected by a flood may vary depending on the type of PePav scientific and engineering solutions. Anyway, more positive attitudes towards PePav solutions and the fact that a close person was affected by the flood lead to a greater *willingness* of respondents to accept it. On the other hand, having experience in the field of building a residential unit or commercial space for yourself leads to greater restraint.

The fact that the students from different study group (Psychology, Hydraulic and Environmental Engineering, and Construction Project Management) show significantly different *attitudes* toward PePav are remainder of the importance of planning the group of stakeholders regarding their education, occupation, professional position, and experience, also.

6. Limitations

The presented results are preliminary and represent initial insights into complex activities during the implementation of scientific and technological solutions in the prevention of urban pluvial floods.

The sample was convenient and did not include all relevant stakeholder groups. First of all, in further steps, it will be *necessary* to include different general population strata to which those solutions may be relevant. Among them, construction management, engineers, workers, and public policy maker are groups of special interest in the next stage of research.

During the analyses, into account were taken the *attitudes* towards PePav technologies and *acceptance willingness*. Created scales (PRS, NRS, PWU and NWU) showed satisfactory metric characteristics. In a short time, with a minimal examinees burden, they provide numerous significant data for understanding the phenomenon they are intended to measure. But, some of the opposite attributes (*risky/safe-harmful/harmless; useless/useful-unnecessary/necessary*) seem to overlap. This brings the question and the idea of redundancy. There are several things to consider. These attributes were obtained from relevant literature and respondents' answers in the preparatory phase to the question - which attributes would they use to describe PePav solutions in general? Then, the meaning of the attribute is determined not only by the attribute itself, but also by the pair in which it is included. The selection of final items from the primary pool was based on psychometric characteristics. The correlations obtained between the items of the final scale were at a low to moderate level. Finally, it is important to take into account the language in which the survey was conducted - in Serbian, there are subtle but clear differences between the above attributes. Apart from the problem of item exclusivity and exhaustiveness, there is another topic to consider. Namely, in relevant literature, the most commonly used Theory of planned behaviour as a conceptual framework proposes that knowledge, motivation, beliefs, and social pressure are also important if we want to properly understand planned behaviour (e.g. acceptance *willingness*). Cross-validation studies are the next step in the development of this part of Ø-Waste-Water research activities.

Finally, it would be important to examine the impact of broader social determinants such as the context of public policies and legislation.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Snezana Svetozarevic, Vladana Rajakovic Ognjanovic, Branislava Lekic and Aleksandar Radoje Savic;* ***data collection:*** *Snezana Svetozarevic, Vladana Rajakovic Ognjanovic, Branislava Lekic and Aleksandar Radoje Savic;* ***analysis and interpretation of results:*** *Snezana Svetozarevic, Vladana Rajakovic Ognjanovic, Branislava Lekic and Aleksandar Radoje Savic;* ***draft manuscript preparation:*** *Snezana Svetozarevic. All authors reviewed the results and approved the final version of the manuscript.*

Ethics Statement

This study was reviewed and approved by the Ethics committee of Faculty of Philosophy, University of Belgrade, Serbia (05/2-7 № 1067/1).

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