1 **Behavioural Informatics for Improving Water Hygiene Practice based on IoT**

2 **Environment**

3

4 Abstract: The development of Internet of Things (IoT) and latest Information and Communication

5 Technologies (ICT) have changed the nature of healthcare monitoring and health behaviour intervention in

6 many applications. Water hygiene and water conservation behaviour intervention as important influence

7 factors to human health are gaining much attentions for improving sustained sanitation practice. Based on

8 face-to-face delivery, typical behaviour intervention method is costly and hardly to provide all day access to

9 personalised intervention guidance and feedbacks. In this study, we presented a behavioural information

10 system and water use behaviour model using IoT platform. Using Expanded Theory of Planned Behaviour

11 (ETPB) and adopted structure equation model, this study offers a solution for understanding the behaviour

12 intervention mechanism and methodology for developing empirical model. A case study of behaviour

13 intervention model is presented by utilising residential water conservation behaviour data collected in China.

14 Results suggested that cultural differences have significant influences on the understanding of intervention

15 drivers, promoting projects and increasing awareness, which could improve the behaviour intervention

16 efficiency and further facilitate the improvement of water hygiene practice. The performance evaluation of

17 water saving dimension is discussed as well in the paper.

18

21

22 **Introduction**

23 Contaminated household environment and risky hygiene practices cause a big amount of disease burden in

24 developing country. The lack of good water supply and prevalence of risky hygiene behaviour could cause

25 life years lost, infectious diseases and plague, as well as large economic losses and negative publicity to

26 governments. Overwhelming evidences suggest that predicting the behaviour change has significant positive

27 influence on addressing these concerns [1]. This paper aims to enhance water hygiene practices through

28   understanding water use behaviour in IoT enabled environment to further improve water demand and water

29   quality management, which the optimal water operation and management will directly impact on the

30   consumers' water hygiene practice and reduce the risk of causing the disease to improve the public health.

31   This paper will provide the necessary tools for improve sanitation and substantial reduction in water supply

32   needs, gain more attentions by the water utilities, food industry and academy, due to the consequence to

33   human health and influence on fresh water ecosystems [2]. When residents use less water in a specific time,

34   the more chlorine should be added to maintain the disinfection level of the clean water. Also, the demand and

35   water use behaviour in different area could affect the operations (supply amount and treatment process) of

36   different treatment works in the same water network. Thus, understanding of water use behaviour will benefit

37   water demand management, and plays key role in water network management and reducing the vulnerability

38   of freshwater supply (such as researches at Advizzo and iWidget). Moreover, the understanding of water use

39   behaviour could contribute to optimize water demand and water quality management to improve the water

40   hygiene practice for public health.

41

42   Belonging to the general healthcare practices research domain, the water hygiene and its behaviour

43   intervention issues, are challenging tasks to clinicians and decision maker who are seeking to monitor

44   behaviour and transfer medical advices in to intervention guidance [3]. Water related behaviour varies

45   differently by areas, also, many water use related behavioural interventions have not yet been empirically

46   investigated because they do not lead themselves to study under existing research paradigm [4]. Models

47   including the Theory of Planned Behaviour [5], the theory of reasoned action and Schwartz's norm activation

48   model etc., have been applied to investigate the conserving water issues during water scarcity period in many

49   developed countries, such as USA [6], UK [7], Australia [8] and Greece [9]. However, there are lack of

50   evidences that explain residential water conservation behaviour via theoretical viewpoints in different

51   background especially in a multi-purpose methodology to generate empirical model. One of the few

52   exceptions is Zhang and Brown [10] who found that household water using habits and behaviour (physical

53   behavioural pattern) as well as a household' willingness to respond to water related strategies has positive

54   influence on their water consumption amount. Chen et al. [11] studied the relationship between social-

55   psychological and residential characters of water scarcity on the one hand and drinking water choices on the

56   other. He found that personal health belief and other characters (income, education etc.) are affected domestic

57   drinking water choices in Shanghai. These studies do not, however, address on the issues of that how water

58   use behaviour change can be influenced and what the adaptability for a psychological theory is in different

59   cultural background. Therefore, there is a need to develop understanding of the residential water conservation

60   behaviour intervention mechanisms. This research thus tries to fill the gaps.

61

62   Moreover, limited by the face to face delivery method, the behaviour intervention of water hygiene is costly

63   and hardly to cover large amount users with 24 hours' access of the intervention guidance and the intervention

64   process management information [12]. Despite the IoT environment allows the provision of healthcare

65   behavioural information to every user and monitoring all the participants' actions with the capacity of

66   tracking and screening the users remotely [13, 14, 15]. Current IoT healthcare systems have not shown

67   enough capability to understand water related behaviour intervention in psychological viewpoints. Azzawi et

68   al. [16] and Prochaska [17] systematically reviewed the current healthcare information system, and concluded

69   that most healthcare related IoT systems mainly concerned physical actions/behaviours by using sensor

70   devices, RFID (Radio-Frequency Identification) [18, 19, 20] or other methods. In line with this finding, Jun

71   et al. [21, 22] and Sultan et al. [23] conducted comprehensive survey of IoT based healthcare system and

72   supported above findings in different digital platforms. Less evidences are proved that the psychological

73   behavioural intervention could be effectively monitored in IoT environment. By way of an IoT based

74   behavioural data collection and feedback, this paper, therefore is aiming to present an information system for

75   psychological behavioural data management, behavioural intervention model extrapolation and dynamic

76   behaviour modelling. Integrated with behaviour intervention models, this research can offer tailed

77   intervention information to all users and reduce the delivery cost of current behavioural intervention project.

78   It also provides methodology for how to manage health related behavioural data in IoT environment and how

79   to generate empirical and computer models based on IoT data.

80

81   The behaviour intervention model, which can test the past behaviour and self-efficacy as predictor in the

82 whole theory, is based on an expanded version of TPB, and will be different from the original TPB model in

83 the water industry application. Using the corresponding ETPB questionnaire and data collection from smart

84 meters in IoT environment, this study provides empirical evidences about the residential behavioural

85 information toward water conservation strategies during the whole intervention process. Additionally, the

86 model examines the cross-country applicability with respect to the theory application by using model

87 simulation results. This research will ideally provide a first knowledge base for public water conservation

88 strategies and policy development that aim to increase water hygiene project engagement. The structure of

89 this paper is organized as follows. Section 2 presents an overview of IoT based behavioural intervention

90 system architecture. Methodology and data are described in Section 3. Section 4 presents the case study of

91 residential water conservation behavioural intervention. Discussion and conclusion are made in Section 5.

92

93 2 Related Work

94 Extensively research has been done about behavioural intervention. Thomas et al. [24] analysed recent studies

95 published coding behaviour change models for health promotion and through his finding, most commonly

96 behavioural intervention research methods are based on psychological behavioural change theories, including

97 Theory of reasoned action/planned behaviour (TPB), TTM (The Transtheoretical Model), HBM (Health

98 Belief Model) and Social Cognitive Model (SCM) and so on. Theory of Planned Behaviours (TPB) as one

99 of the major predictive social and behaviour models was developed as an extension of the Theory of Reasoned

100 Action (TRA) model and it is a model. The TPB considers the proximal determinant of behaviour is person's

101 intention which is based on attitude (overall evaluations towards performing the behaviour), subjective norms

102 (social pressure from important referents to perform a behaviour) and perceived behavioural control (control

103 on individual believe) [25]. There is systematic and meta-analytical evidence in relation to changes in health

104 behaviour, the predictive performance of both the TRA and the TPB are in most superior to that of the Health

105 Belief Model [26].

106

107 Despite its significance in environmental research, to date, the TPB research became more controversial

108 about its sufficiency and the need for external variables which assist the improvement of intention prediction

109   (see examples [27, 28]). Research findings above have proposed additional predictors to improve the TPB

110   perdition power in intention and behaviour [27,29]. Interestingly, on conceptual level, various divergent water

111   conservation frameworks also exist on adding external determinants (or predictors) to specific behaviour (see

112   examples [30 - 33]). Lam [33] also argued that TPB alone is not sufficient as a basis for understanding people'

113   intention to conserve water. In the safety and water use area, similar arguments about TPB theory could also

114   been found in literature. Inauen [34,35] reviewed thirteen models for predicting behavioural intervention in

115   safe water use area and concluded that TPB has limited prediction capability and there are more constructs,

116   which should be considered to improve its prediction ability. Consequently, some other constructs to TPB

117   will need to be added in order to increase the utility and predictive power for residential water conservation

118   behaviour. The behavioural model applied in this research will add two external constructs and exam the

119   modelling result through case study result. Moreover, according to Hofstede's individualism-collectivism

120   dimension, different individuals from different background may show variable behavioural relations in the

121   TPB model. With the application of IoT environment, many users from different background will participant

122   the intervention process. To increase the modelling accuracy, there is a need to put ETPB variables

123   configuration into consideration in this study. General hypothesis for ETPB framework is present in section

124   3.2 and a model configuration case is given in case study section 4.

125

126   3 Architecture

127   Specified by International Telecommunication Union (ICU), IoT framework is defined into five different

128   layers: perception layer, access layer, internet lay, service management layer and application layer. In this

129   study, the perception layer is consisted of water meter, GPS/sensors and mobile/internet end user platform.

130   The water meter collected water usage readings at different water end use points. GPS/sensors (via mobile

131   phone) are designed to collect and send geographic data to the server. Internet and mobile platform

132   (application) is designed to collect and feedback water use behaviour data, and provide information for all

133   the related water conservation project. The smart water meters are a native long-range solution based on

134   169MHz smart metering frequency band with a transmission range of up to 1 – 1.5 km to a concentrator.

135

136   The IoT based behavioural intervention information system contains data collection and data feedback

137   component. Data is collected via RFID, sensor, wearable device and internet platform. The data for modelling

138   use is made up by expanded Theory of Planned Behaviour questionnaire data (behavioural data) and water

139   usage data. Processed by Structure Equation Model, the system then generates empirical ETPB model with

140   variable identification result. Following by artificial neural network water consumption behavioural model,

141   the system provides all the users with the prediction of their future water usage and their water behavioural

142   intervention pattern. To increase the effectiveness of the whole intervention process, the intervention

143   guidance, in the meantime, is translated by persuasive strategies and gaming mechanism to increase the user

144   acceptance. The system will classify the behaviour via scoring result and feedback the specific behavioural

145   intervention suggestions to the user including "you can do much better than you through via these tips of

146   water conservation" for increasing the subjective norm, "you can install this device to help you save water in

147   a rush time" if the score is low for answering the "how confidence when save water in a rush time".

148   Corresponding local water conservation policy and activities are pushed to the targeted users as well to

149   enhance their water conservation behaviour. Figure 1 presents the IoT- based behavioural information system

150   architecture.

151

152
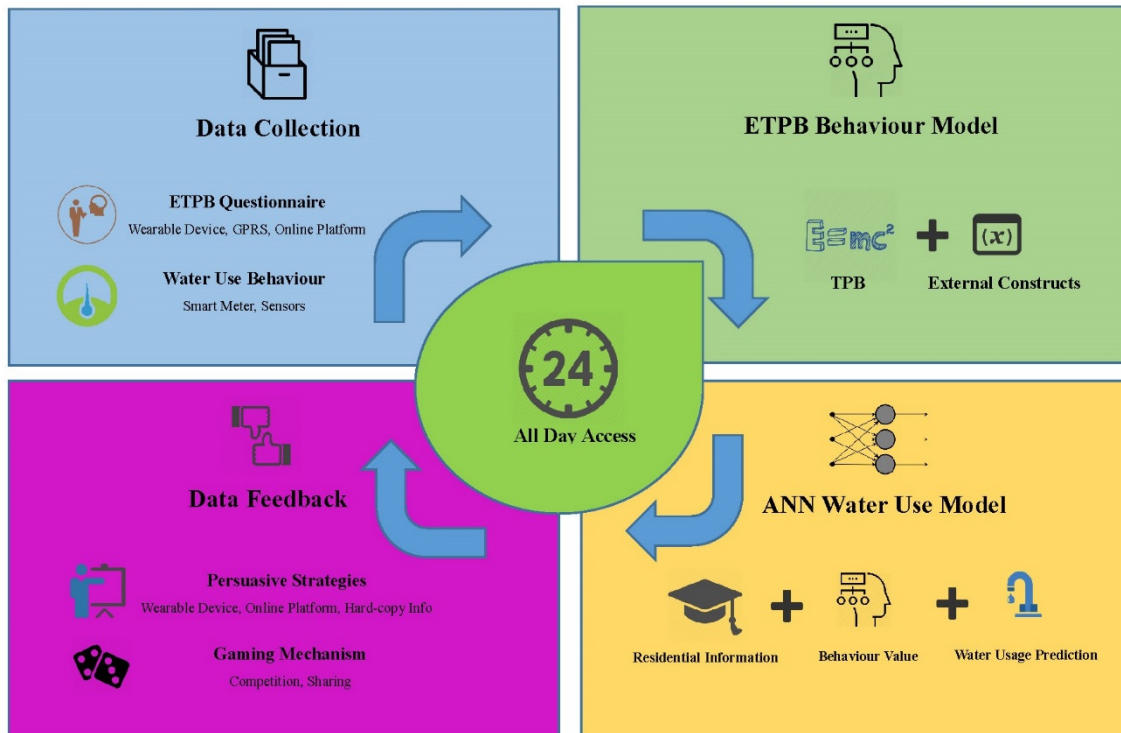
Figure 1. IoT based behavioural information system

154

3.1 Data Collection

The construction for the Expanded Theory of Planned Behaviour questionnaire was generally followed the procedures in Fishbein and Ajzen's discussion [36]. TPB 7-point Likert scales (1 = strongly disagree to 7 = strongly agree) have been applied previously in water conservation behaviour research with similar research purpose, and they have established an acceptable reliability [37, 38]. Apart from the behavioural data, residential character data such as income, education, number of residents are also included in the questionnaire to collect data supporting the ANN water use modelling. In this study, we apply wearable devices and online platform to investigate water use psychological behaviour. Users could access through mobile application or report the location/tag use information through this platform. Water use data is mainly collected from smart meters install for every household and taps need monitor.

165

Instead of using the full-questionnaire, we promoted the simplified question items and easy understanding answers. All the constructs are directly measured using just one single item (such as "how confident you feel

168 you can manage you water conservation activity for this week?" replace the original detailed measurement

169 in the questionnaire). Corresponding direct measurement are following the TPB questionnaire design method

170 (direct measure) published by Ajzen in 1991 [5]. the user will be invited to fulfil a complete detailed

171 questionnaire for every two months.

172

173 3.2 Behaviour Intervention Modelling

174 As discussed above in Section 2, we present the expanded Theory of Planned Behaviour modelling basis and

175 the model is innovative by adding two external variables to increase the prediction power and accuracy.

176 Water conservation regarding to water hygiene, should not only depend on local condition, but also be

177 influenced by historical water use background and freshwater availability in the past [39]. Additionally,

178 another factor called past behaviour, past action, pro-environmental behaviour, self-reported past behaviour

179 or habit, has been added in TPB for improving the explanation of environmental behaviour [28, 37, 40, 41].

180 Ouellette and Wood [42] argue that our actions are not determined by reasoning but by habitual and automatic

181 processes which measured by a past action was engaged. Other authors, by the contrast, have been sceptical

182 of the influence of all independent variables in TPB on intention [343, 44, 45]. In this case study, as residential

183 water conservation habit in the mostly research areas are kept, and likely to affect the influence of attitude,

184 subjective norms and PBC on intention, however, whether the affection is attenuation remains unknown. Our

185 aims, therefore, is to explore its prediction power to water conservation intention and its attenuation affection

186 on TPB variables by adding "past behaviour" in TPB.

187

188 Summarizing, this research added past behaviour and self-efficacy in TPB framework as an extension version

189 to understand how residential water conservation behaviour changes. Figure 2 depicts the proposed expanded

190 theory of planned behaviour. Figure 3 illustrates the structure equation expression of ETPB. By following

191 the general rule of TPB behavioural hypothesis, which is more positive attitude, greater PBC and subjective

192 norm will strengthen the individual' intention to perform a behaviour, thus, construct correlations are

193 expressed as hypothesis in ETPB:

194

195   H1. As attitude towards water conservation became more positive, the residential intention to save water and

196   adopt conservation activity increases.

197

198   H2. As subjective norm towards water conservation became greater, the residential intention to save water

199   and adopt conservation activity increases.

200

201   H3. As PBC towards water conservation became greater, the residential intention to save water and adopt

202   conservation activity increases.

203

204   H4. As self-efficacy about water conservation became more positive, a residential intention to save water and

205   adopt conservation activity increase.

206

207   H5. As past behaviour towards water conservation became more positive, a residential attitude, subjective

208   norm, PBC and self-efficacy on intention towards water saving increase.

209

210   Finally, not only for the direct effects of past behaviour on water conservation intention, but also the indirect

211   effect that between TPB variables will be investigated. Thus, we hypothesized that
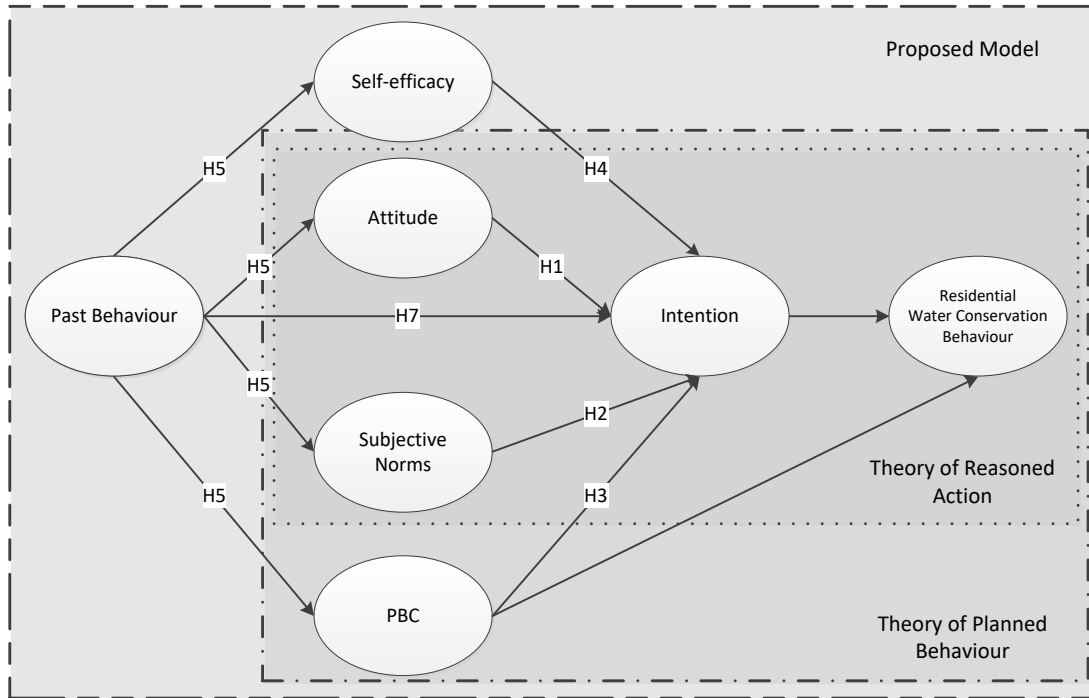
212

213   H6. As the controlling of past behaviour about water conservation became greater, a result of attenuating

214   influence of attitude, subjective norms, PBC and self-efficacy on intention increase.

215

216   H7. Past behaviour indirectly influences water conservation intention through TPB variables (attitude, PBC
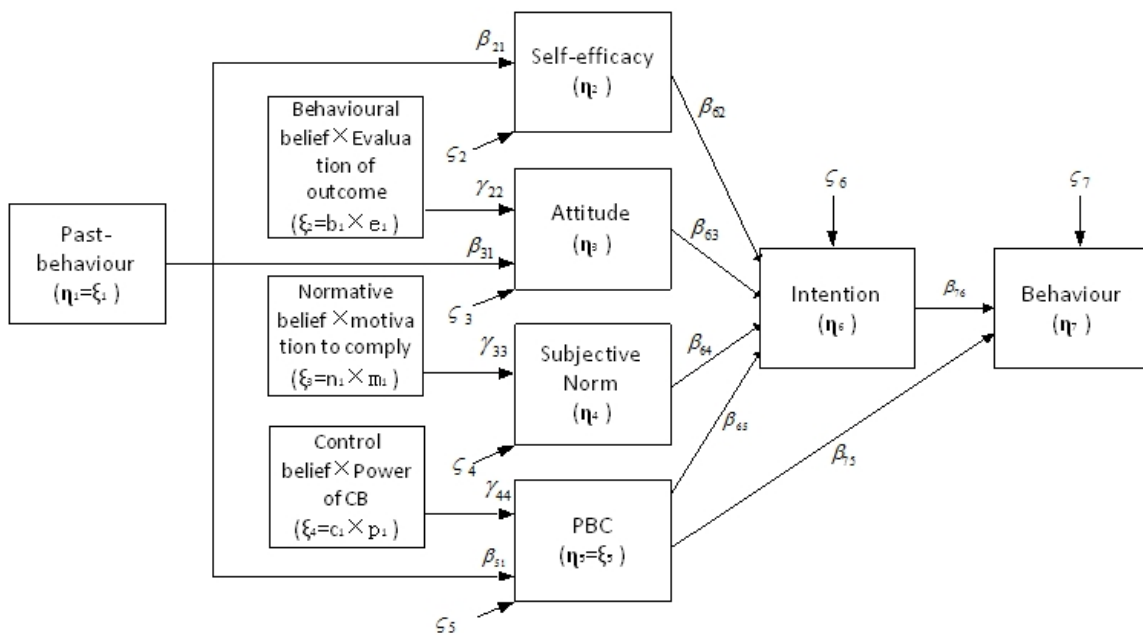
217   and Subjective norms).

218

219
220   Figure 2. Expanded TPB model for residential water conservation behaviour based on TRA and TPB

221

222

223   Figure 3. ETPB Structure Equation expression

224

225   The ETPB model mainly uses the Structural Equation Modelling (SEM) which will make the behavioural

226 model to become a mathematical representation. According to the SEM method, this research will limit us to

227 a special case of it called path analysis. The path analysis model choice a vector η of endogenous variables

228 and a vector ξ of exogenous variables is expressed in Equation (1). Equation (2) is the detailed matrix

229 expression of the past analysis equation.

230
$$\eta = B\eta + \Gamma\xi + \xi \qquad (1)$$

231
$$
\begin{bmatrix} \eta_1 \\ \eta_2 \\ \eta_3 \\ \eta_4 \\ \eta_5 \\ \eta_6 \\ \eta_7 \end{bmatrix} =
\begin{bmatrix}
0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 \\
\beta_{61} & \beta_{62} & \beta_{63} & 0 & 0 & 0 & 0 \\
0 & 0 & \beta_{73} & \beta_{74} & \beta_{75} & 0 & 0
\end{bmatrix}
\cdot
\begin{bmatrix} \eta_1 \\ \eta_2 \\ \eta_3 \\ \eta_4 \\ \eta_5 \\ \eta_6 \\ \eta_7 \end{bmatrix}
+
\begin{bmatrix}
\gamma_{11} & 0 & 0 \\
0 & \gamma_{22} & 0 \\
0 & 0 & \gamma_{33} \\
0 & 0 & 0 \\
0 & 0 & 0 \\
0 & 0 & 0 \\
0 & 0 & 0
\end{bmatrix}
\cdot
\begin{bmatrix} \xi_1 \\ \xi_2 \\ \xi_3 \end{bmatrix}
+
\begin{bmatrix} \xi_1 \\ \xi_2 \\ \xi_3 \\ \xi_4 \\ \xi_5 \\ \xi_6 \\ \xi_7 \end{bmatrix}
\qquad (2)
$$

232 Where B and Γ are β_{ij} and γ_{ij}'s matrices regression weights, respectively, and ξ is a vector of

233 disturbance variables.

234

235 3.3 ANN Water Use Model

236 Feeding back the predictive amount of water use for every user could promote the intervention project, also,

237 makes visualisation of behaviour intervention outcome. Psychological notion for behaviour in behavioural

238 intervention theories means the outcome of the behavioural intervention. However, for water conservation

239 project, a calculated behaviour value cannot represent all the meaning of users' behavioural intervention

240 outcome, moreover, there is dimension difference between psychological behaviour value and physical water

241 saving amount. Fu and Wu [46] proposed a water use modelling method to generate water consumption

242 amount by using ETPB model. The dynamic modelling algorithm is applied in this IoT based behavioural

243 information system. Figure 4 illustrates the ANN water use model structure. In the ANN model, the

244 psychological data is firstly being processed in ETPB model to simulate behavioural change result. Combined

245 with other residential variables, calculated in ANN water consumption model to predict future water use

246 amount. All the variables definition can be found in the literature [46].

247

248 The study used multiple-layer ANN networks. This multi-layer networks consist of an input layer of value

249 consisting of House Size (HS), Number of Resident (NOR), Month (M), Education Level (EL), Income Level

250 (IL) and Behaviour Value (BV) from ETPB Questionnaire, two hidden layers of perceptron and an output lay

251 for outputting the Water Consumption Data (WCD with a unit of Ton/month). Numbers of nodes in hidden

252 layer is set as two. BV (Questionnaire Calculated Behaviour Value) is calculated according to empirical ETPB

253 model regression weight. The artificial neural network for household water consumption is expressed as

254 Equation (3).

$$WCD = F(W_2 F(W_1 R + \Psi_H I) + \Psi_0 I) \tag{3}$$

256 Where WCD is the standardized water consumption data as output vector, R is the standardized input vector

257 which consisting house size (HS), number of resident (NOR), month (M), education level (EL), income level

258 (IL) and questionnaire calculated behaviour value (BV); F(x) is the sigmoid function; W_1 is the weight

259 vector between input and hidden layer; W_2 is the weight vector between hidden and input layer; Ψ_H and

260 Ψ_0 are the threshold vectors of hidden layer and output layer; I is an unit matrix. The mean prediction error

261 (%) of water consumption model based on ANN between the original data and predication data is less than

262 0.8% presented in previous publication [46].

263

264 3.4 Data Feedback

265 Interactive information technology designed for individual behaviour change is known as persuasive

266 technology [47]. The persuasive technology contains three phases for promoting the intervention information,

267 which are understanding the key issue of the system, analysing the persuasion context (intent, event, strategy)

268 and system quality design. Previous researches applied persuasive technology in healthcare domain won

269 success in the past decade [48]. By introducing the game mechanism in persuasive design step two, the IoT

270 system could feedback water use prediction result via social media and wearable device competition game

271 mechanism and sharing function. Gaming function design includes the awarding system, water conservation

272 riddle, Facebook/Twitter sharing, 3D visualisation for water saving outcomes. The game mechanism applied

273 in this IoT system has been proved efficient in many previous projects such as FitBit, Ubifit, HealthMath and

274 Nike Pulse etc.
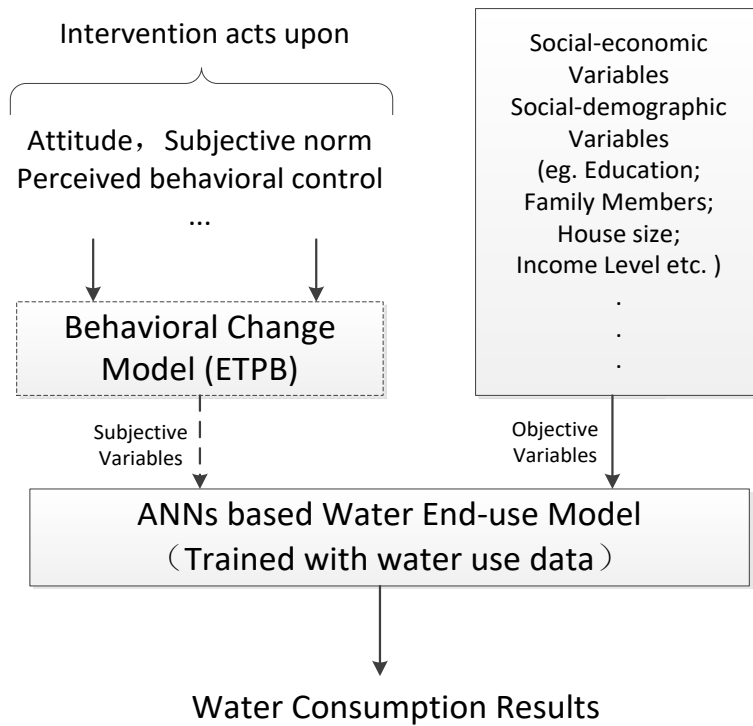
Figure 4. ANN water use model[46]

4. Case Study and ETPB Calibration

To test the ETPB model and the empirical model calibration ability of the IoT system, a case study in China is conducted. The data collected from this case is applied for the test of ETPB model configuration and hypothesis testing. To exam ETPB questionnaire and guarantee the reliability of the data collection method, a pilot study is conducted in the research area. Following by a national wide survey, 3000 residents from four different areas are invited to join our research. Sampling result and questionnaire content are given in Section 4.1 and 4.2. ETPB model calibration is presented in section 4.3. Section 4.4 and 4.5 presented the role of self-efficacy and past behaviour.

4.1 Sampling

Prior to the data collection, a pilot study based on face-to-face interview, was carried out on a sample of 23 subjects to ensure the validity of the ETPB questionnaire setting. This pilot study was refined through water conservation experts and residents' reviews in order to guarantee the validity and

291   readability. SZ, a southern city of China facing critical water problem and has high population mobility,

292   was finally chosen as a representative location for conducting pilot study. SZ is a new developed mega

293   size city and most of its populations are from other provinces. SZ is also acting as the pioneer of water

294   conservation project in China and has its own water conservation association for handling all the water

295   conservation promotion. There are 84 face-to-face interviews with equal male and female quotas, carried

296   out with respondents who were voluntarily be chosen to complete questionnaire in the town centre. 13

297   questionnaires had to be removed due to the inconsistencies and incomplete data. On average,

298   respondents took 8-17 minutes to complete the questionnaire with fully understanding of the content.

299

300   The follow-up national wide data collection for this research was conducted from September 2014 to

301   July 2015. The behaviour data collection system was set with a submission decline when indicates

302   uncompleted questions, thus, missing values will not occur in the dataset. Also, in order to increase

303   honest responses, the internet survey was designed to offer an anonymous feeling with a preamble

304   advising [44]. Before the respondents start to complete questionnaire, introduction of preamble advising

305   which is mentioned the importance of this research and faithful reply, was given in the study. Two

306   criteria were set before the questionnaire being processed: the respondents should be over 18 years old

307   and know very well about daily water use activity in their property.

308

309   By concerned the precipitation and water distribution condition, evenly, 3,000 participants from four

310   different regions list of China (East coast (wet zone with abundant water resources from Yangtze and

311   Zhu rivers), Central China (multi-water zone and humid areas in the middle stream of Yangtze and

312   Xiang rivers), Northeast China (sub-humid and transition zone), Western China (semi-arid and drought

313   area), excluding Hong Kong and Taiwan) represent, somewhat, to the Chinese population with quotas

314   set for age, gender and education, being invited to fulfil questionnaire thorough the link via social media

315   and email, leading to a final sample size 417 respondents (13.9% recycle rate). 19 responses were

316   disregarded by online system because the questionnaire completion time is extremely low (5 min) and

317   be processed as untrusted. Additional, 17 extreme cases were eliminated through a test of multivariate

318 outliers' identification with a use of criterion Mahalanobis' distance P < .001, retaining a final sample

319 volume of 381 cases. The sample results have shown almost equivalent numbers of male and female

320 participants: 47.2% male respondents and 50.6% female respondents. The mean age is 37 years

321 (standard deviation 18) with 39.7% high school education background responses.

322

323 **4.2 Questionnaire**

324 The construction for the Expanded Theory of Planned Behaviour questionnaire was generally followed

325 the procedures in Ajzen's discussion [34]. TPB 7-point Likert scales (1 = strongly disagree to 7 =

326 strongly agree) have been applied previously in water conservation behaviour research with similar

327 research purpose, and they have established an acceptable reliability [37,38]. All the constructs that

328 related to residential water conservation behaviour, are shown sufficient reliability. Cronbach alpha

329 reliability coefficient of the sampling shown in Table 1 were applied with a result of good-to-excellent

330 reliability ranging from 0.6 to 0.9.

331

332 **Table 1.** Survey questions, reliability and validity test results

Scales	Mean (s.d.)	CR	AVE
Intention (α=0.886)	**2.450(1.313)**	**0.7765**	**0.7028**
I expect I will engage in everyday actions to save water around my property	2.261(1.095)		
I intend to engage in water conservation activities in the near future	2.793(1.102)		
I plan to conserve water around my property in the near future	2.367(1.461)		
Attitude (α=0.867)	**2.352(1.029)**	**0.7678**	**0.7913**
I think engage in water conservation activities is beneficial	2.297(1.632)		
I think engage in water conservation activities is valuable	2.794(1.184)		
I think engage in water conservation activities is pleasant	2.435(1.093)		

I think engage in water conservation activities is good	2.103(1.615)		
I think engage in water conservation activities is intelligent	2.333(1.567)		
I think engage in water conservation activities is necessary	2.349(1.494)		
Perceived behaviour control (α=0.951)	**2.458(2.928)**	**0.9451**	**0.7423**
To what extent do you feel capable of conserving water when the water price is low	4.326(1.939)		
To what extent do you feel capable of conserving water when it is inconvenient	4.164(1.834)		
To what extent do you feel capable of conserving water when you are in a rush	3.653(2.305)		
Subjective norms (α=0.915)	**4.190(1.802)**	**0.9861**	**0.9220**
People who are important to me think that I should conserve water	4.354(1.681)		
People who are important to me expect that I will conserve water	3.836(1.933)		
I feel like there is social pressure to conserve water	3.964(1.238)		
The people whose opinions I value would conserve water	4.262(1.768)		
Self-efficacy (α=0.984)	**3.909(1.927)**	**0.9455**	**0.8526**
For me to conserve water around my living place is easy	2.635(2.387)		
I am confident that I could save water around the house and garden if I want	2.244(2.108)		
The decision to save water around the house and garden is under my control	2.302(1.164)		
I have the time and skills needed for water conservation activities	2.713(3.152)		
Past behaviour (α=0.909)	**2.889(1.407)**	**0.9640**	**0.8173**
check and fix leaking tap in the last six months	2.876(1.884)		

use minimal water in kitchen in the last six months	2.941(1.801)		
collect rainwater to use in the last six months	2.352(1.364)		
turn off taps when brushing teeth in the last six months	2.319(1.298)		
have shorter showers (4 min or less) in the last six months	2.166(1.033)		
only run washing machine if it is full in the last six months	3.136(1.641)		
Water conservation behaviour (α=0.973)	**3.721(2.359)**	**0.9683**	**0.8595**
I reuse water	2.530(2.174)		
I apply numerous water conservation technology	2.237(2.091)		
I participate water conservation activities	3.983(1.882)		
I check and repair leakage	2.148(2.014)		
I follow the government water conservation policy	3.155(2.263)		

333 Note. C.R.: Composite reliability; AVE: The average variance extracted.

334

335 **4.3 ETPB Calibration**

336 A Confirmatory Factor Analysis (CFA) using maximum likelihood method was conducted to test

337 construct validity for proposed latent variables. Model goodness-to-fit was assessed with various

338 measures as below: x^2 (chi-square), Goodness of Fit Index (GFI), Root Mean Square Error of

339 Approximation (RMSEA), Comparative Fit Index (CFI), Incremental Fit Index (IFI, also known as

340 DELTA2), and Tucker-Lewis Index (TLI, also known as NNFI). The good-of-fit x^2 is very sensitive

341 to sample size and the large chi-square value of CFA reveals a high degree of freedom.

342

343 A CFA test for the original TPB model (model 1) with attitude, PBC and subjective norms was initially

344 conducted. The first CFA shown a good fit of the structural equation modelling (x^2= 837.347, df=335,

345 GFI=0.768, RMSEA=0.089, IFI= 0.950, TLI= 0.943, CFI= 0.949). Another CFA test for TPB model

346 with external construct – self-efficacy (model 2) also exhibited good psychometric properties (x^2=

347 957.463, df=414, GFI=0.763, RMSEA=0.083, IFI= 0.951, TLI= 0.944, CFI= 0.951), following by a

348 good CFA fit test result from the proposed expanded TPB (model 3) which contains past behaviour and

349   self-efficacy as external constructs (x^2= 1310.423, df=603, GFI=0.735, RMSEA=0.079, IFI= 0.945,

350   TLI= 0.939, CFI= 0.945).

351

352   Additionally, variable composite reliability test for proposed model indicating high internal consistency,

353   shown all reliability values were greater than suggested threshold of 0.60. As an assessment of the

354   validity of the measures, factor loading within all the indicators, AVE (Average Variance Extracted),

355   and construct correlation were calculated and depicted in Table 1. The result indicated an adequate

356   convergent validity with all factor loading values, AVE, CR were above 0.5, 0.6 and 0.7 respectively.

357   The hypotheses 1, 2 and 3 were initially tested by original TPB structural model (model 1, see Figure

358   2) which has a satisfactory model fit (x^2= 844.867, df=340, GFI=0.766, RMSEA=0.088, IFI= 0.949,

359   TLI= 0.943, CFI= 0.949) and all standardized regression coefficients were significant at 0.01 level.

360   Based on the coefficients in the equation, the three antecedent variables (see Figure 5) explained about

361   28% variance of intention and the four TPB variables (including intention) contributed 39% variance

362   percentage for predicting water conservation behaviour. The regression paths from PBC (β=0.273,

363   t=4.319, p< 0.01), subjective norms (β=0.235, t=3.710, p< 0.01) and attitude (β=0.293, t=4.600, p< 0.01)

364   to intention were significant, therefore, H1, H2 and H3 are accepted.
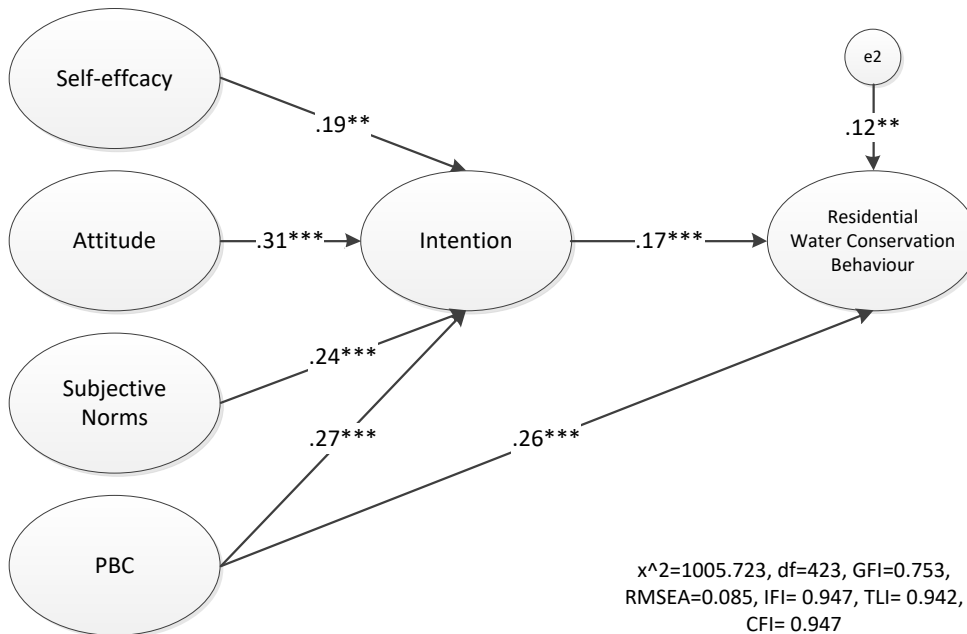
365
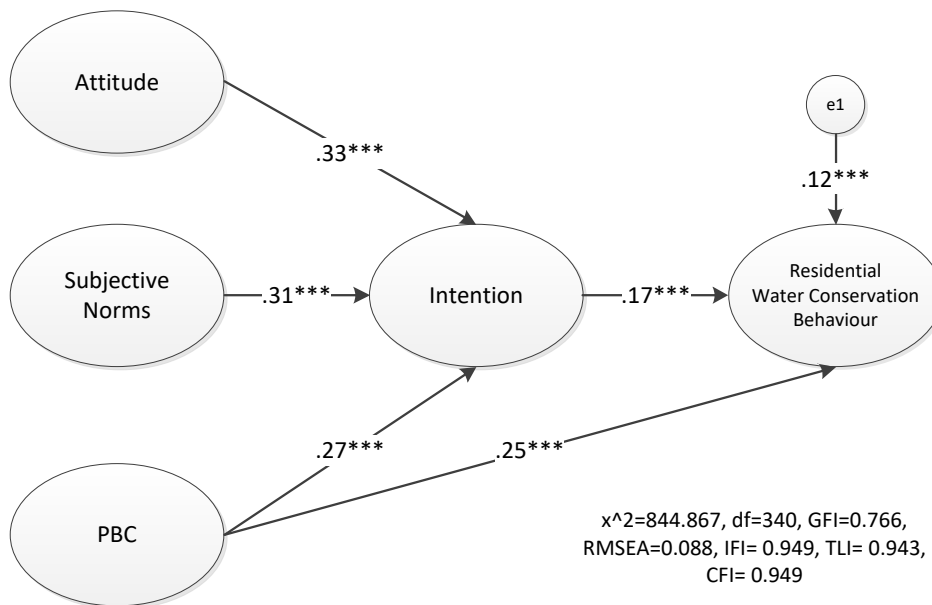
366

367   ***p < 0.01; **p < 0.05; ⁻p >0.05.

368   **Figure 5.** TPB (model 1) Structural Equality Model explaining water conservation behaviour

369   (Standardized Solution Values)

370

371   An augmented version of the TPB was tested by model 2 to determine the influence of self-efficacy as

372   a predictor of residential water conservation behaviour. The TPB model with external construct self-

373   efficacy (model 2, see Figure 6) has a good model fit as well (x^2= 1005.723, df=423, GFI=0.753,

374   RMSEA=0.085, IFI= 0.947, TLI= 0.942, CFI= 0.947). All the structural standardized coefficients are

375   significant and self-efficacy appears to have an attenuation influences on relationship of model 1 where

376   regression paths from PBC (β=0.223, t=2.443, p< 0.01), Subjective norms (β=0.212, t=3.157, p< 0.01)

377   and attitude (β=0.264, t=4.129, p< 0.01) to intention decreased. Self-efficacy (β=0.168, t=2.443, p< 0.01)

378   was found to be positively and significantly associated with intention which confirmed the H4, and self-

379   efficacy explained 12% variance of intention with the water conservation behaviour explained by all

380   five variables was 43%.

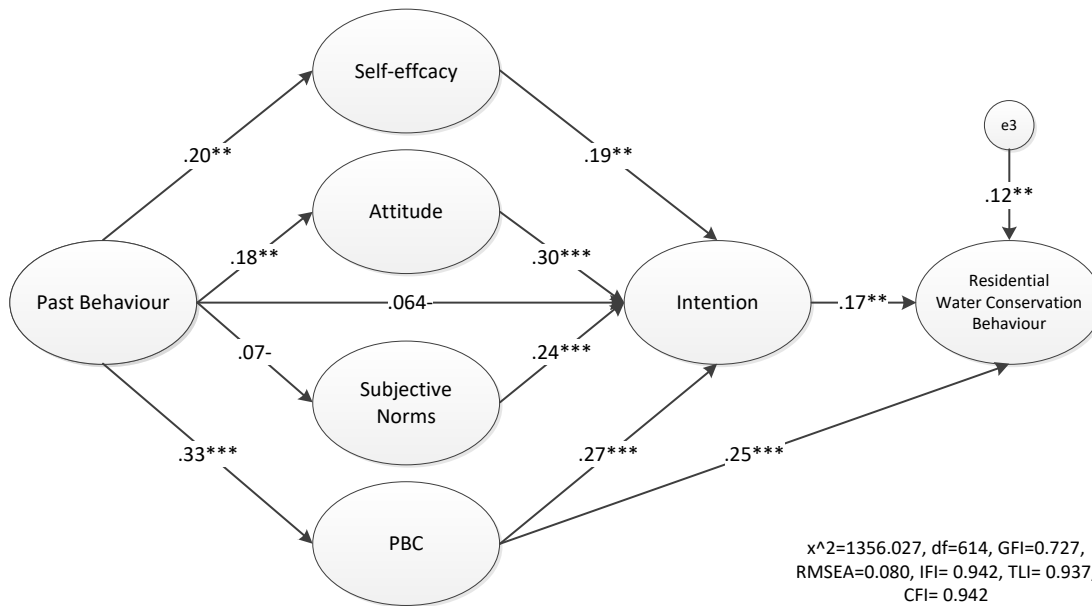381

382

383   ***p < 0.01; **p < 0.05; ⁻p >0.05.

384   **Figure 6.** TPB with self-efficacy (model 2) Structural Equality Model explaining water conservation

385   behaviour (Standardized Solution Values)

386

***p < 0.01; **p < 0.05; ⁻p >0.05.

Figure 7. Proposed ETPB (model 3) Structural Equality Model explaining water conservation behaviour (Standardized Solution Values)

The proposed model (model 3, shown in Figure 7) provided a satisfactory fit (x^2= 1356.027, df=614, GFI=0.727, RMSEA=0.080, IFI= 0.942, TLI= 0.937, CFI= 0.942). The majority of the structural regression coefficients are again significant (p<0.01), apart from the past behaviour to subjective norms (p>0.05). H5 was tested. Results shown that pas behaviour has a positive influence on water conservation intention (β=0.196, t=2.757, p< 0.01), attitude (β=0.179, t=2.502, p< 0.05), PBC (β=0.380, t=5.468, p< 0.01), self-efficacy (β=0.302, t=3.104, p< 0.01) and subjective norms (β=0.076, t=1.053, p> 0.05), thus, H5 was partially confirmed. In order to evaluate the H6, the 95% confidence intervals ($CI_{0.95}$) for standardized coefficients [29] was performed in model 2 and model 3. There is overlap occurred for the confidence intervals of the PBC-intention standard coefficient in model 2 ($CI_{0.95}$= 0.21≥0.27≥0.39) and model 3($CI_{0.95}$= 0.14≥0.27≥0.32), and no significant attenuation of model relationships is shown as a result of the past behaviour inclusion, therefore H7 is rejected. In the proposed model, all variables (past behaviour, subjective norm, PBC, intention and attitude) accounted for 49% of the variance in

404 water conservation behaviour. Based on above finding, the Chinese residential behaviour intervention

405 ETPB model transfer weight can be calibrated and applied for the future use and the model has been

406 proved significant for behavioural intervention investigation.

407

408 **4.4 The role of Self-efficacy and PBC**

409 In previous research, studies (such as [27]) have already pointed out that using principal components

410 factor analysis method could identify the distinction between PBC and Self-efficacy. In this research,

411 the principal components analysis (KMO value = 0.845, Chi-square = 929.538, df=21, p<0.001) with

412 factor matrix rotation produced PBC and self-efficacy are shown in table 2. PBC is significantly related

413 to the external beliefs such as water price and in the inconvenient water use circumstance. Self-efficacy

414 is not associated with these items, but with the belief related to confidence to save water and control of

415 water conservation decision making. The result provided evidence for discriminate validity between the

416 two conceptualizations of control. In Figure 6, it also shown that the inclusion of self-efficacy in the

417 original TPB model did not attenuated the relationship between PBC and intention, which indicated the

418 variance that PBC shares with intention is not accounted for by self-efficacy. This support the findings

419 that have made the distinction between self-efficacy and PBC in water conservation application.

420

421 **Table 2.** Distinguishing self-efficacy in TPB: rotated factor matrix for principal components analysis

	Factor Loading	
Items	PBC	Self-efficacy
To what extent do you feel capable of conserving water when the water price is low	0.862	0.268
To what extent do you feel capable of conserving water when it is inconvenient	0.881	0.216
To what extent do you feel capable of conserving water when you are in a rush	0.790	0.304

For me to conserve water around my living place is easy			0.372		<u>0.659</u>	
I am confident that I could save water around the house and garden if I want			0.397		<u>0.861</u>	
The decision to save water around the house and garden is under my control			0.194		<u>0.847</u>	
I have the time and skills needed for water conservation activities			0.235		<u>0.763</u>	

4.5 The role of Past Behaviour

In this study, mediation analysis is performed to fully understand the inclusion of past behaviour to the original TPB model relationship. The Sobel test and bootstrapping method (with default N=1000 bootstrap resamples) were used to calculate the indirect effects from it. The Sobel test describes the mediator potency by creating the asymptotic standard error using multivariate delta method [50]. Analysis process is performed by a SPSS-micro which offers an estimation of indirect effect and 95% Monte Carlo confidence interval with effect size measures [51].

The finding in Table 3 revealed that past behaviour cannot significantly affect water conservation intention through Subjective norms. All the other indirect influencing relationship from past behaviour to intention were significant, thus, H7 was partially confirmed. The bootstrap results also reveal that all the significant indirect effects are trusted between zero for the predicted confidence intervals except from relationship of "Past Behaviour → Subjective Norms → Water Conservation Intention". These findings indicated that residential past water conservation behaviour does not have significant mediating role in the relationship between Subjective norms and water conservation intention.

Table 3. Indirect effects

Independent variable	Mediator	Dependent variable	Effect size	se	Mediation confidence interval	
					Lower	Upper

Past Behaviour	Attitude	WCI	0.0554**	0.0303	0.0147	0.1404
Past Behaviour	PBC	WCI	0.0857***	0.0446	0.0194	0.1996
Past Behaviour	Subjective Norms	WCI	0.0230-	0.0238	-0.0260	0.0680
Past Behaviour	Self-efficacy	WCI	0.0620**	0.0253	0.0209	0.1253

440   ***p < 0.01; **p < 0.05; ¬p >0.05.

441

442   **5. Discussion and conclusion**

443   Little research has focused on residential water conservation decision-making process in IoT

444   environment. This research proposed a behavioural information system for understanding the water

445   conservation behaviour and lead to enhance water demand and water quality management, these will

446   facilitate water hygiene practise to improve public health and prevent disease due to risky water hygiene

447   practice. By incorporating two constructs in TPB: frequency of past water conservation behaviour and

448   self-efficacy as significant predictors of residential water conservation behaviour, the proposed system

449   explained 49% of the variance in the extended TPB model. Our findings are comparable to previous

450   studies of water conservation behaviour in the USA [6], UK [7], Australia [8] and Greece [9]

451   demonstrating the universality of the TPB to predict residential water conservation behaviour.

452

453   The IoT system has been proved to offer easy access to healthcare related behaviour. From our project,

454   the system increased the delivery speed and offered all day access to the intervention guidance. This

455   system somehow can improve the effect of the behaviour intervention project delivery. Moreover,

456   through our communication with our users, there are a lot of users willing to try IoT technologies and

457   agreed the 24/7 easy access method. Different from individualistic cultures (e.g. UK or US), people in

458   our research area emphasize shared values and are relative loyal to the collective "we", has its

459   uniqueness cultural background, according to Hofstede's individualism-collectivism dimension. High

460   power distance, which refers to the high extent of individuals' acceptance that government of

461   organization is distributed equally, as another label for Chinese culture also makes Chinese residents

462   perceive lower internal control locus with a belief that certain behaviour is more influenced through

463   their own decision and evaluation. Louise et al. [49] argued that the effect of subjective norm on

464   intention would be stronger in countries high in collectivism and power distance. Our findings support

465   this argument, having a larger correlation (standard solution value 0.31 in model 1) for the relation

466   subjective norms (SN) to intention. In the TPB theoretical application perspective, these findings about

467   Chinese culture differences have important practical implications for water conservation project

468   managers in understanding drivers of residential water conservation behaviour and when starting

469   marketing promotions across nation. The impact of subjective norm on conservation intention is greater

470   in China, thus, promotion messages should likely be more effective in persuading residents to participate

471   the water conservation activities compared to individualistic and low power distance countries.

472

473   Attitude was the strongest predictor of residential water conservation intention in this study, having a

474   larger coefficient than all other constructs in both TPB and ETPB models. This result is consistent with

475   previous finding [53] in Bulgaria which attitude is the most effective TPB component on water

476   conservation intention followed by PBC and subjective norm. Absolute scores of TPB questionnaire

477   items measuring attitude and PBC were relatively low, while those for subjective norms and self-

478   efficacy tended to be high. Overall, residents have received a positive social pressure to perform water

479   conservation behaviour, attempts should be made to increase attitude and PBC among users. The low

480   attitude score indicated that even Chinese government has intensively promoted its water conservation

481   project, residents do not have enough awareness to its importance. Providing residential educational and

482   positive persuasive information through TV, WeChat, Weibo or other media channels are likely to

483   increase the acceptance of water conservation projects. Regarding to PBC, Blanke et al. [54] argued that

484   policy supporting institutions should provide in some case financial assistance and coordination to help

485   resident conquer external barriers. The ratio of investment in water conservancy project to capital

486   construction investment for China was less than 2% during 2005-2009. Raising more investments from

487   third parties or NGOs and proportion of government water conservation investment could, therefore,

488   help to current Chinese water conservation projects. All the behaviour intervention modelling result will

489   be written as guidance and published on behavioural intervention platform by using data feedback

490   method in this study.

491

492   As shown in Table 3, this study indicated that among the four mediator variables in proposed ETPB

493   model, only subjective norms cannot significantly mediate the impact of past behaviour on water

494   conservation intention. This finding implied that past behaviour shapes attitude, self-efficacy and PBC

495   towards a behaviour, and these will enhance residential water conservation decision. Accordingly, water

496   conservation project managers should consider the residential water conservation background areas

497   before starting to promote and install water conservation technologies. It is suggested that water

498   conservation technologies should fit past residential water conservation background (behaviour). For

499   example, if the residents in an area have a long-term habit to take short shower, the corresponding

500   technologies in enhanced shorter shower time will be more easily to gain success in the case. And the

501   development of more effective water conservation strategies is essential to improve their residential

502   experiences while participate a project.

503

504   The present study in this paper contributes to examine the past behaviour influence on residential water

505   conservation intention, attitude, PBC, subjective norms and self-efficacy, which are little addressed. The

506   Control of past water conservation behaviour did not attenuate the influence of TPB relationship and

507   self-efficacy which is consistent with Hagger's findings [29, 39], but in contrary to the previous studies

508   (see examples [40, 43]). The lack of social cognitive attenuation influence by past behaviour suggests

509   that past water conservation behavioural engagement does not has the similar cognitive-reducing

510   influences on residential water conservation intentions that reported in literature. One of the possible

511   reason may be that most residents do not have organized past behavioural patterns in study care.

512

513   Moreover, apart from research findings, several limitations of this study should be pointed out. Firstly,

514   due to the complexity of the behavioural information format, this information system based on IoT

515   environment did not address the translation method for other behavioural information such as image

516   and video. Further research, therefore, will investigate more detailed solutions for translating

517 behavioural information from other channels. Secondly, this system only shown capability to study

518 individual's behavioural intervention process, however, for a community and city level, the modelling

519 method in the system cannot work very effectively due to the theory basis we applied in this research.

520 We will apply a community based behavioural intervention model in the system to simulate large

521 population's behaviour in the future research. Adding the populated information in the consumption

522 modelling process could ideally offer a solution for this limitation. Thirdly, some other analysis and

523 machine learning technologies such as cluster analysis and decision tree are also suggested for digging

524 more information of behaviour, should be considered to apply in the further research.

525

526 Acknowledgement

527

531

532 Reference

533

534 [1] Davis, R., Campbell, R., Hildon, Z., et al., 2014.Theories of behaviour and behaviour change across the

535 social and behavioural sciences: a scoping review', Health Psychol. Rev., 8, pp. 1–22.

536 [2] Pagella, C., Galli, R., De Faveri, D.M., 2000. Water reuse in industrial food processing. J. Food Technol.

537 Africa, 5 (1), pp. 25–29.

538 [3] Mark, J., Carl, M.: 'Promoting professional behaviour change in healthcare – what interventions work,

539 and why? Protocol for a theory-led overview of systematic reviews', BMJ Open, 2015, 5, (9), pp. 1–10.

540 [4] Australia Psychological Society, Evidence-based Psychological Interventions in the Treatment of Mental

541 Disorder: A   Literature   Review,   Australia   Psychological   Society,

542 https://www.psychology.org.au/Assets/Files/Evidence-Based-Psychological-Interventions.pdf,   2010

543 (accessed 02/01/2017).

544　[5] Ajzen, I., 1991. The Theory of Planned Behavior. Organizational Behavior and Human Decision Process,

545　50, pp. 179-211.

546　[6] Pirie, R.L., de Loë, R.C., Kreutzwiser, R., 2004. Drought planning and water allocation: an assessment

547　of local capacity in Minnesota. J. Environ. Manag. 73 (1), pp. 25-38.

548　[7] Gilg, A., Barr, S., 2006. Behavioural attitudes towards water saving? Evidence from a study of

549　environmental actions. Ecol. Econ. 57 (3), pp. 400-414.

550　[8] Hurlimann, A., Dolnicar S., Meyer, P., 2009. Understanding behaviour to inform water supply

551　management in developed nations-a review of literature, conceptual model and research agenda. J. Environ.

552　Manag. 91 (1), pp. 47-56.

553　[9] Jones, N., Evangelinos, K., Gaganis, P., Polyzou, E., 2011. Citizens' perceptions on water conservation

554　policies and the role of social capital. Water Resour. Manag. 25 (2), pp. 509-522.

555　[10] Zhang, H.H., Brown, D.F., 2005. Understanding urban residential water use in Beijing and Tianjin,

556　China. Habitat International. 29, pp. 469-491.

557　[11] Chen, H., Zhang, Y., Ma L., Liu, F., Zheng, W.,2012. Change of water consumption and its potential

558　influential factors in Shanghai: a cross-sectional study. BMC Public Health. 12:450.

559　[12] Fu, Y,, Wu, W., 2016. Predicting Household Water Use Behaviour for Improved Hygiene Practices in

560　Internet of Things Environment via Dynamic Behaviour Intervention Model. IET Networks, 5(5), pp. 143-

561　151.

562　[13] Alok, K., Sampada, S., 2014.Healthcare applications of the internet of things: a review, Int. J. Comput.

563　Sci. Inf. Technol., 5 (5), pp. 6229–6232.

564　[14] Yang, P., Stankevicius, D., Marozas, V. et al., 2016. Lifelogging data validation model for internet of

565　things enabled personalized healthcare. IEEE Transactions on Systems, Man and Cybernetics: Systems, PP

566　(99), pp. 1-15.

567　[15] Phillip, L., Mohamad, K., Nancy, L., et al., 2017. Building Caring Healthcare Systems in the Internet of

568　Things. IEEE Systems Journal, PP (99), pp. 1–8.

569　[16] Azzawi, M, A,. Hassan, R, H,. and Bakar, K, A, A,. 2016. A review of Internet of Things (IoT) in

570　Healthcare, International Journal of Applied Engineering Research, 11(20), pp. 10216-10221.

571 [17] Prochaska, J. J., & Prochaska, J. O. (2011). A Review of Multiple Health Behavior Change Interventions

572 for Primary Prevention. American Journal of Lifestyle Medicine, 5(3), 10.1177/1559827610391883.

573 http://doi.org/10.1177/1559827610391883

574 [18] Po, Y., Wu. W., M. Moniri and C. C. Chibelushi, 2013. Efficient Object Localisation Using Sparsely

575 Distributed Passive RFID Tags, IEEE Transactions on Industry Electronics, 60(12), pp. 5914-5924.

576 [19] Po, Y., Wu, W., 2014. Efficient Particle Filter Localisation Algorithm in Dense Passive RFID Tags

577 Environment, IEEE Transactions on Industry Electronics, 61(10), pp. 5641 - 5651.

578 [20] Po, Y., 2015. Experimental Evaluation and Analysis of Achieving High Accuracy and Precision in

579 Passive HF RFID Location Systems, IEEE Internet of Things Journal. 2, pp.159-167.

580 [21] Jun, Q., Po, Y., Geyong, M. et al., 2017. Advanced internet of things for personalised healthcare systems:

581 a survey. Pervasive and Mobile Computing, 2, pp. 132-149.

582 [22] Jun, Q., Po, Y., Martin, H. et al., 2016. Multiple density maps information fusion for effectively assessing

583 intensity pattern of lifelogging physical activity, Neurocomputing. 220, pp. 199-299.

584 [23] Sultan H. Almotiri, Murtaza A. Khan, Mohammed A. Alghamdi, 2016.Mobile Health (m-Health)

585 System in the Context of IoT, IEEE International Conference on Future Internet of Things and Cloud

586 Workshops (FiCloudW), pp. 39-42. 10.1109/W-FiCloud.2016.24

587 [24] Thomas, W., Judith, J., Lucy, Y., et al., 2012. Using the internet to promote health behaviour change: a

588 systematic review and meta-analysis of the impact of theoretical basis, use of behaviour change techniques,

589 and mode of delivery on efficacy, J. Med. Internet Res., 12, (1), e4

590 [25] Ajzen, I., 1985. From Intentions to Actions: a Theory of Planned Behavior, in: Julius Kuhl, Jurgen

591 Beckmann. (Eds.), Action Control. Springer, Berlin, pp. 12-39.

592 [26] Taylor, D., 2006. A Review of the use of the Health Belief Model (HBM), the Theory of Reasoned

593 Action (TRA), the Theory of Planned Behaviour (TPB) and the Trans-Theoretical Model (TTM) to study and

594 predict health related behaviour change. National Institute for Health and Clinical Excellence, Manchester.

595 [27] Conner, M., Armitage, C.J., 1999.Extending the Theory of Planned Behavior: A Review and Avenues

596 for Further Research. Journal of Applied Social Psychology. 28, pp. 1429-1464.

597 [28] Hasbullah, D., Mahajar, A.J., Salleh, M.I., 2014. Extending the theory of planned behavior: Evidence of

the arguments of its sufficiency. International Journal of Humanities and Social Science. 4(14), pp. 101-105.

[29] Hagger M. S. Chatzisarantis, N., Biddle, S.J., Orbell, S., 2001. Antecedents of children's physical activity intentions and behaviour: Predictive validity and longitudinal effects. Psychology & Health. 16, pp. 391–407.

[30] Jorgensen, B., Graymore, M., O'Toole, K., 2009. Household water use behaviour: An integrated model. Journal of Environmental Management. 91, pp. 227-236.

[31] Leviston Z., 2005. Towards Sustainable Irrigation Practices: Understanding the Irrigator. A Case Study in the Riverland-South Australia. CSIRO, Dickson. http://catalogue.nla.gov.au/Record/3773200, 2005 (05/01/2017 access).

[32] Gregory, G.D., Leo, M.D, 2003. Repeated behaviour and environmental psychology: the role of personal involvement and habit formation in explaining water consumption1. Journal of Applied Social Psychology. 33, pp. 1261–1296.

[33] Lam, S.P., 2006. Predicting intention to save water: theory of planned behaver, response efficacy, vulnerability, and perceived efficiency of alternative solution1. J. Appl. Sco. Psychol. 36(11), pp. 2803-2824.

[34] Inauen,, J., 2012. Theory-based promotion of safe water consumption. Dissertation. University of Zurich, Department of Psychology.

[35] Inauen, J., Mosler, H.R., 2016. Mechanisms of behavioural maintenance: Long-term effects of theory-based interventions to promote safe water consumption. Psychol Health. 31(2), pp.166-183

[36] Fishbein, M., & Ajzen, I., 2010. Predicting and changing behavior: The reasoned action approach. New York: Psychology Press.

[37] Dolnicar, S., Hurlimann, A., Grun, B., 2012. Water conservation behaviour in Australia. Journal of Environmental Management. 105, pp. 44-52.

[38] Yazdanpanah, M., Hayati, D., Hochrainer-Stigler, S., Zamani, G.H., 2014. Understanding farmers' intention and behaviour regarding to water conservation in the Middle-East and North Africa: A case study in Iran. Journal of Environmental Management. 135, pp. 63-72.

[39] Hoekstra, A.Y., 2000. Appreciation of water: four perspectives. Water Policy. 1(6), 605-622.

[40] Sommer, L., 2011. The theory of planned behaviour and the impact of past behaviour. International

625   Business and Economic Research Journal, 10(1), pp. 91-110.

626   [41] Hagger M. S., Chatzisarantis, N., Biddle S.J., 2001. The influence of self-efficacy and past behaviour

627   on the physical activity intentions of young people. Journal of Sports Sciences. 19(9), pp. 711-725.

628   [42] Ouellette, J.A., Wood, W., 1998. Habit and intention in everyday life: The multiple processes by which

629   past behaviour predicts future behaviour. Psychological Bulletin. 124, pp. 54-74.

630   [43] Norman P., Conner, M., Bell, R., 2000. The Theory of Planned Behaviour and exercise: Evidence for

631   the moderating role of past behaviour. British Journal of Health & Psychology. 5, pp. 249-261.

632   [44] Terry, D.J., O'Leary, J.E., 1995. The Theory of Planned Behaviour: The effects of perceived behavioral

633   control and self-efficacy. British Journal of Social Psychology. 34, pp. 403-415.

634   [45] Yordy, G.A., Lent R.W., 1993. Predicting aerobic exercise participation: Social cognitive, reasoned

635   action, and planned behaviour models. Journal of Sport and Exercise Psychology. 15, pp. 363-374.

636   [46] Fu, Y., Wu, W. 2015. Simulation and conservation of the end use water based on behaviour intervention

637   modelling, Procedia Engineering, 119, pp. 761-770.

638   [47] Fogg, B.J, Persuasive Technology: Using Computers to Change What We Think and Do. San Franciso:

639   Morgan Kaufmann Publishers, 2003.

640   [48] Intille, S. S. 2004. Ubiquitous Computing Technology for Just-in-Time Motivation of Behavior Change,

641   Studies in Health Technology and Informatics, 107(2), pp. 1434-1437.

642   [49] Babbie, E., 2013. The Basics of Social Research, Sixth ed. Wadsworth Publishing, Belmont.

643   Bandura, A., 1997. Self-efficacy: The exercise of control, First ed. Freeman, New York.

644   [50] López-Mosquera, N., Garcia, T., Barrena, R., 2014. An extension of the Theory of Planned Behavior to

645   predict willingness to pay for the conservation of an urban park. Journal of Environmental Management. 135,

646   pp. 91-99.

647   [51] Hayes A. F., 2013. Introduction to Mediation, Moderation and Conditional Process Analysis, First ed.

648   Guilford Press, New York.

649   [52] Louise, H., Edward, S., Sara, P., 2016. Addressing the cross-country applicability of the theory of

650   planned behaviour (TPB): A structured review of multi-country TPB studies. J. Consumer Behav. 15(1), pp.

651   72-86.

652   [53] Clark, W.A., Finley, J.C., 2007. Determinants of Water Conservation Intention in Blagoevgrad, Bulgaria.

653   Society and Natural Resources, 20(7), pp. 613–627.

654   [54] Blanke, A. et al., 2007. Water saving technology and saving water in China. Agr. Water Manage. 87, pp.

655   139-150.