# TRIZ Evolution Trend-Based Public Service Innovation for Enhancing Social Participation of Life Garbage Classification

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June 23, 2021

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**Abstract.** With the advent of the sustainable development era and the mature emerging technologies, the flexible waste management mode to solve various kinds of realistic problems is possible. For this potential, this paper proposes a methodology aiming at public service innovation based on TRIZ evolution theory and a case study of Xi'an city is implemented to demonstrate the method's effectiveness. In the first phase "public service diagnosis," the problems are identified as "Insufficient social subjects participating," "Inadequacy of real-time management monitoring," "Inaccuracy of collection routing and time setting," and "Irrationality of facility establishing." In the second phase "TRIZ strategies deduction," throughout trends analysis, TRIZ strategies are generated, which includes "Independent participation strategy," "Potential motivation strategy" and "Flexible treatment strategy." Finally, in the third phase (public service conceptualization), a new service system which named "Green Chain Smart Recycling and Processing System" (GC-SRPS)" is proposed, which devotes to waste management service innovation.

**Keywords:** TRIZ Evolution Trends, Public Service Design, Life Garbage Classification.

## 1 Introduction

The management of life garbage has become a significant problem in urban environmental protection process. The treatment of waste is a very important issue in the current public service and it influences the resource allocation in sustainable development. In recent years, China has launched the "Healthy China" strategy in 2019 and a Trash Segregation Planning (TSP) policy was published in Shanghai, China in 2019. The implementation of the policy also reflected a lot of problems, such as an increasingly serious "garbage siege" and frequent resource conflicts. At present, the traditional means of waste management in various cities are difficult to meet the realistic need, and the treatment effect is limited (Wang et.al., 2019). With the big data era, emerging technology has brought a new revolutionary wave. It's increasingly employed in all fields of society and plays an important role. Information technologies are increasingly being applied in urban waste management in China, such as the grid management in Beijing, the big data management platform for garbage classification in Guangzhou, and so on.

Big data real-time monitoring, dynamic analysis, prediction and early warning and other technologies become excellent, which are providing new ideas and treatment for domestic urban waste management (Gan & Zhang, 2020). The attention should focus on how to make a bridge between technology performance and the realistic demands. In other words, how to apply technology to meet the public demand becomes a significant issue.

In view of the advantage of TRIZ theory, this research proposes an innovative public service design model which is devotes to connect the realistic demand into the system function according to the industry development trends. Meanwhile, an empirical case with the waste management service design in Xi'an is presented in this article.

## 2 Literature Review

TRIZ (Theory of Inventive Problem Solving) was proposed by the Russian researcher, Altshuller (1984), who found that very creative patents solve "creative" problems, which usually have the features of paradoxical and conflicting demands (Altshuller, 1984; Lee et al., 2015). TRIZ is a knowledge-based systematic methodology that provides a logical approach to developing creativity for innovation and inventive problem solving (Ilevbare et al., 2013; Souchkov, 1997; Savranksy, 2000). It can provide a systematic approach for ones who are with less experience but attempt to seek for innovative solutions with concepts of contradiction, evolution and resources (Altuntaş & Yener, 2012). Initially, it was mainly applied in the technical field to solve the engineering problems. Researches on the inventive tools of TRIZ are mainly focus on the industrial engineering, research, and development (R&D) (Ninan et al., 2019; Asyraf et al., 2019; Carrara, 2020), and industrial service innovation (Lee & Trappey, 2014).

Perfect ideas are difficult to extend to specific domain applications. TRIZ generalizes and summarizes the common characteristic of reasonable solutions, resolves the contradictions considering available resources and the current situation. (Altshuller, 1999; Gazem and Rahman, 2014; Jiang et al., 2011). Therefore, TRIZ is a useful invention theory based on engineering creativity and it can be applied to both more tangible product manufacturing and engineering fields and other more intangible service, marketing, financial and education fields. (Gazem and Rahman, 2014; Jiang et al.,2011; Lee et al., 2015). To explore the viability of applying TRIZ to service design problem solving, Wang et al. (2017a, 2017b) proposed a four-dimension holistic approach for new service design with different patterns. Shahin and Pourhamidi (2011) developed the service TRIZ for service quality design, which innovatively modified the traditional 39 parameters into 12 ones and proposed a 12*12 non-technical contradiction matrix for problem-solving service applications. Lee, Wang, Trappey, and Yang (2014), Lee, Wang, and Trappey (2015b) applied a TRIZ-based service design approach to develop new location-based services in the fast-food restaurant industry and intelligent parking service in a shopping mall. Chai et al. (2015) proposed a new TRIZ-based approach combined to overcome the experience-oriented difficulties in the traditional service design process with two empirical cases to verified the validity. Lee et al. (2020) put forward a novel knowledge-centric innovative service design (KISD) model that combined

TRIZ method and CBR to generated great ideas for the customized, innovative service design. Wang (2018) integrated rough set theory with a fuzzy cognitive pairwise rating, and Kansei engineering with TRIZ to develop a consumer product design platform. Chiou et al. (2012) used TRIZ in the convention and exhibition industry to carry out systematic innovation. TRIZ is now increasingly used in service design in the banking, marketing, management, education, hospital, healthcare, hospitality and airline service sectors (Chiou et al., 2012; Hartono, 2016; Jeeradist et al., 2016; Shahin & Pourhamidi, 2011, Gazem & Rahman, 2014; Lee & Trappey, 2015; Li et al.,2020). TRIZ evolution is one of TRIZ's toolkit. It devotes to investigate deeply in the past development and further direction of a certain industry, so that the government or enterprise can optimize resource allocation in advance to meet further needs (Fey & Rivin, 2005). TRIZ evolution trend theory is a suitable tool to connect the technical performance and design requirements.

TRIZ-based method is adopted as the service design method, and lack of review on using the method on the service design of public service (Lee & Trappey, 2015). Thus, it is adopted for the case in this study to explore the new era. It also enriches the application of TRIZ-evolution. The TRIZ-based method allows the design of new and inventive services focusing on defining and solving public service problems with non-experiential domain background using the knowledge base (Lee & Trappey, 2014). Therefore, this study will enrich the article in the application of TRIZ evolution trends into the public service innovation area under the background of smart city governance.

## 3 Research Framework

This research proposes a new public service design model that provides systematic design methodology toward achieving service innovation with development rule of the public service industry. The service design methodology includes four phases, namely **(1) Public service diagnosis, (2) TRIZ strategies deduction, and (3) Public service conceptualization,** as shown in Fig. 1.

**Phase 1-Public service diagnosis**

In this phase, the main target contains drawing out the citizen's demands and conducting the context analysis to explore the dilemma of current industry. The specific steps are as follows: a) Context analysis, b) Problem definition. Through literature review and reports, we grab a deep understanding in the service situation and try to define the service problems. During the collection and analyzing process, recordings and transcripts are encoded for the further research. By summarizing the above issues, the problems in the public service industry can be defined.

**Phase 2-TRIZ strategy deduction**

The primary purpose of this phase is to deduct the service design strategy combining the diagnosed service problem and the TRIZ revision evolution trends. It includes a) Trend revision. b) Stage assessment. and c) Trend application. First, modify the 37 industrial TRIZ evolution trends to adapt to the smart public service field toward investigating the development laws. Then, according to the modified TRIZ evolution trends, we evaluate and judge the current stage of industry development. Finally, design strategies for service innovation are generated.

**Phase 3-Public service conceptualization**

This phase primarily completes the conception construction for the public service from the TRIZ strategies angle. The process contains a) Function creation, b) Visualization representation. Primarily, the system functions are generated based on the TRIZ design strategies aiming at solving the industry dilemma. Then, the outcomes and its relationship present in the way of vivid graphic representations.

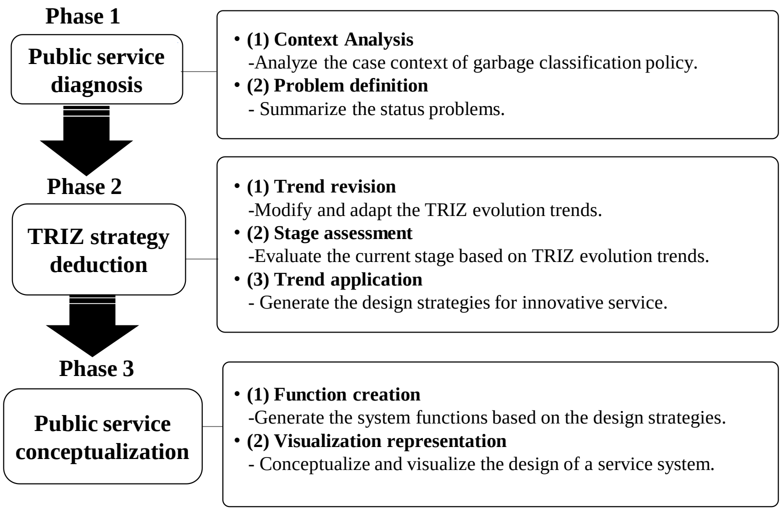


**Fig. 1.** Research framework of the public service system conceptualization

based on TRIZ design strategy

## 4 Case Study

An empirical study in Xi'an city for designing a new public service system under the smart waste management scenario was conducted to demonstrate the feasibility of the above proposed methodology. Due to different cities different city governance problems will reflect, in this empirical case, the urban development of Xi'an will be taken as an example for illustrating the status quo of waste recycling and processing to seek the innovative service to support smart waste management process.

### 4.1 Case Background

A Trash Segregation Planning (TSP) policy was launched in Shanghai on 1 July 2019. Accordingly, Xi'an implemented the policy of "Measures for the Classification and Management of Domestic Waste" in September and the waste classification propaganda activities immediately held in communities, schools, and other places. However, many problems have been exposed in all steps of waste management in the policy implementation process. Thus, we try to identify the problems in Xi'an city and use the above framework to find the smart solution to improve the efficiency of waste management.

## 4.2 Public service diagnosis

### 4.2.1 Context analysis

The types of garbage classification in Xi'an can be clarified into four kinds: recyclable waste, harmful waste, kitchen waste, and other waste, while the garbage treatment chain includes four steps: classifying, taking out, transporting, and recycling garbage. Through the whole operation process, many factors may lead to the inefficiency of waste disposal. The immersive investigation for the practical scenarios is conducted by organizing related literature work and news report in order to have a deep understanding for the current situation. We converge the articles and news reported in the last three years which is correlated to the Xi'an scene. The all materials are encoded for the further study.

### 4.2.2 Problem Definition

Four outstanding problems needed to be solved in Xi'an waste management are summarized as follows.

**Problem 1: Insufficient of social subjects participating (P1)**

The cooperation problem between social subjects and government ones is reflected in two aspects. One is that the Xi'an citizen lacks general knowledge to take part in in waste management with social entities. They are unable to clear about the classification types for some garbage. For example, dry batteries should be sorted to other garbage rather than harmful garbage. Another is the muted enthusiasm for the citizen to participate in waste management remain a low level. There exits lack of communication and feedback channels between government and social subjects, which cause the mutual trust among governance bodies at a low degree and make it difficult to supervise and coordinate with each other.

**Problem 2：Inadequacy of real-time management monitoring (P2)**

There is a lag between problem identification and resolution so that the governance entities cannot achieve effective detection and early warning. First, the absence of the detection equipment and warning system make it "easier" to release the pollutants by waste treatment factories. For example, Xi'an Weida Company lacks real-time monitoring of some pollutant emissions such as dioxins when disposing medical waste. Second, it is sort of real-time positioning and accurate detecting of garbage recycling facilities. The supervision on waste dropping during transportation in Xi'an mainly rely on manual irregular inspections and reports from the masses. Obviously, this will result in a hysteretic nature in problem identification and settlement.

**Problem 3：Inaccuracy of collection routing and time setting (P3)**

Xi'an as a huge, populous city owns many garbage collection stations. It means that the garbage transport routes in Xi'an stay complex and long journey. The garbage transport may hit the rush hours because of the overlaps with main road, which can cause two negative effects: First, traffic jams during rush hours may also affect the efficiency of garbage transportation. Second, the poor performance of garbage trucks and the non-standard operation of workers will cause secondary pollution for roadway like noise, waste dropping.

**Problem 4：Irrationality of facility establishing (P4)**

It is not fully considered about the quantity and layout of waste treatment facilities, and they run out of rationality in a certain extent. First, the treatment facilities, like the number of garbage transport vehicles, garbage cans, cannot match with the garbage output in Xi'an. Faced with the huge amount of garbage in Xi'an, insufficient garbage disposal equipment may bring about some negative effect, such as the delayed garbage removal, the place scarce to stack garbage, and random dumping of garbage. Second, when planning the location and layout of some waste treatment equipment and facilities in Xi'an, inadequate consideration has been given to the environment factors, such as surrounding human settlements, natural environment, and traffic environment. For example, the garbage compression stations around residential areas could seriously affect the lives and work of residents. Third, waste treatment equipment is heavily dependent on human resources and the small number of intelligence equipment leads to low efficiency.

## 4.3 TRIZ strategies deduction

### 4.3.1 Trend revision & Stage assessment

Through literature review, we teased 37 industrial evolution trends. Then, 20 evolutionary trends in the service domain have been proposed by experts and industry insiders. Based on the development status of the waste management domain, we deduce a concrete explanation of these 20 evolution trends and assess the current stage in the trends, as shown in Appendix- TRIZ Evolution Trend for Waste management. In view of the length, four examples are illustrated as follows.

**TRIZ trend #7-User to interact with management**

The participation of citizens in waste management has experienced from passive to initiative, to independent participation, as seen in Table 1. According to the P1, the current situation is in the first stage. The public passively meets the governance demands, and the enthusiasm for participation is still at a low degree. In the future, people will use some smart equipment to support the self-participate in the waste management process.

**Table 1.** The specific evolution trends in waste management for #7

| 37evolution TRIZ trends | Revision trends after interviewing practical experts | Specific evolution process in waste management process |
|---|---|---|

| | | |
|---|---|---|
| 15.Boundary break-down | User to interact with management (#7) | Passively meet management needs - Actively interact with the demands - Independently participate in the waste treatment process |

**TRIZ trend #4-Attitude towards user feedback**

The attitude towards user feedback transform from the passively handle complaints to actively listen to the voice of the people. As you can see in Table 2, the development direction is providing closed-loop feedback service which help in the effectiveness for the treatment of user complain. Based on the P2 and P3, managers passively handling the problems only rely on reports by the masses presently.

**Table 2.** The specific evolution trends in waste management for #4

| 37evolution TRIZ trends | Revision trends after interviewing practical experts | Specific evolution process in waste management process |
|---|---|---|
| 6.Macro to Nano | Attitude towards user feedback (#4) | Passively manual deal with user's complaints→ Actively listen to user's opinions→ System-driven closed-loop service feedback. |

**TRIZ Trend #3-Adaptability to the external environment**

In terms of external environmental adaptability, managers make a transition from making response to environmental risks to actively taking environmental factors into consideration, then giving adjustments accordingly, as shown in Table 3. Considering the P3 and P4 above, environmental factors are not rolled in the distribution of garbage collection stations, the program of transportation vehicles routes as well as the layout of garbage treatment facilities, resulting in slow rate in garbage treatment. Its future development path is to actively consider environmental influence and integrate the waste management process with the environment.

**Table 3.** The specific evolution trends in waste management for #3

| 37evolution TRIZ trends | Revision trends after interviewing practical experts | Specific evolution process in waste management process |
|---|---|---|
| 3.Non-linearities | Adaptability to the external environment (#3) | Address environmental risks passively→ Detect and quick response to environmental changes with flexibility |

**TRIZ Trend #19-Decreasing human involvement**

In order to improve efficiency, garbage management is bound to experience the evolution from the process of massive human participation to the directly data flow automation, as seen in Table 4. In accordance with P4, waste disposal equipment relies heavily on human resources and it will realize intelligent management.

**Table 4.** The specific evolution trends in waste management for #19

| 37evolution | Revision trends after interviewing | Specific evolution process in waste management process |
|---|---|---|

| TRIZ trends | practical experts | |
|---|---|---|
| 35.Decreasing human involvement | Decreasing human involvement (#19) | Mass human participation→ Semi-automated machine participation→ Automation of data flow |

#### 4.3.2 Trend application

Based on the above evolution trends, three TRIZ design strategies are deduced: independent participation strategy, potential motivation strategy and flexible treatment strategy. The detailed descriptions are as follows.

**Strategy 1: Independent participation strategy (S1)**

At present, the service delivery process is becoming more and more virtual and initiative, which means service providers are required to allow users to participate in the service process independently (#7). This may ask the provision of assistant equipment permit independent service possible. For example, practitioners can improve the accuracy of garbage sorting by providing intelligent devices with citizens in the step of garbage classification. Specifically, it can be realized precisely and rapidly by means of AI image recognition and other technologies on mobile phones.

**Strategy 2: Potential motivation strategy (S2)**

In the aspect of attitude towards user feedback (#4), service feedback provides information inspiration in the motivation rewards for the policy executors and this mechanism can be employed in the system closed-loop design. For example, service providers can inform users the garbage disposal results and the final benefits of garbage collection, and reward points will greatly improve the enthusiasm of garbage classification.

**Strategy 3: Flexible treatment strategy (S3)**

Considering adaptability to external environment (#3), the service industry is required to respond to environmental changes more flexible and quickly. That means it is important to give a quick response for the real-time situation. Customized route for the garbage recycling vehicle can fluctuate according to the real-time full degree of the waste bin. The automation of data flow (#35) is also demanded to reduce human participation and service providers need to handle daily operations with intelligent equipment swiftly.

### 4.4 Public service design & conception

Basing on the above three TRIZ strategies, a public service system for the smart waste management is constructed, named “Green Chain Smart Recycling and Processing System” (GC-SRPS). The system functions connect the four garbage management scenarios smartly and efficiently using data flow, as shown in the Fig. 2. The specific explanation is shown in the following part.

#### 4.4.1 Function creation.

**Classification assistance**

As S1 can see, some equipment can give assistance in the self-participation process. Users may use a smartphone with augmented reality (AR) technology to scan the garbage for object and category recognition. Installing a radio frequency identification (RFID) scale and an electronic screen on the waste bin can help to identify and confirm the Quick Response Code (QR) code on waste bag. As objects are tossed into the bin, a scale system detects the change in weight and triggers a subsequent treatment message that slides, scrolls or pops onto the screen. For example, some recycling garbage used to compost for poverty alleviation and it can give spiritual encouragement subconsciously. This smart waste system offers a dynamic, educational experience.

**Smart waste bin**

For the S2, feedback information helps in stimulate mechanism. This smart waste bin offers an interactive and educational experience for citizen. Users may trigger the system with the smartphone to get the recycling, tracking, reward information and the macro waste management performance about protecting the earth. Information can be revealed on the digital signage of it. Installing an RFID scale and an electronic screen on the waste bin can help to identify and confirm the QR code on waste bag. As objects are tossed into the bin, a scale system detects the change in weight and triggers a subsequent treatment message that slides, scrolls or pops onto the screen. For example, some recycling garbage used to compost for poverty alleviation and it can give spiritual encouragement subconsciously. This smart waste system offers a dynamic, educational experience.

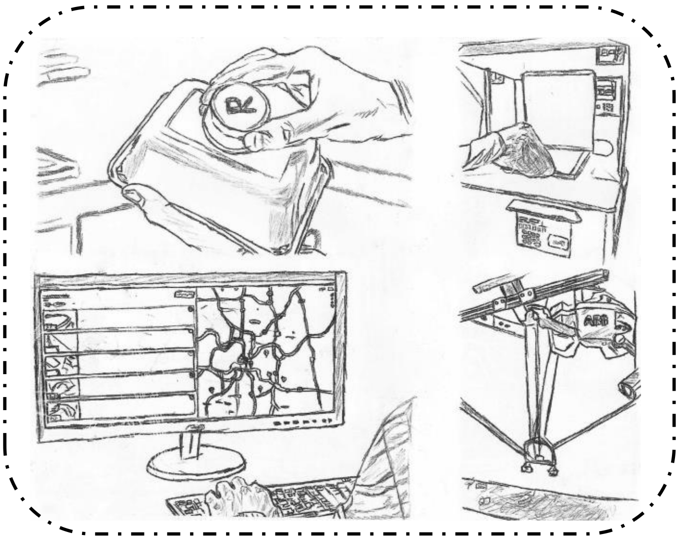

**Fig. 2.** The realistic scene figure of system functions

**Intelligent vehicle route**

Proactive responsiveness to environmental factors and data automation for the intelligent equipment contribute to the flexible handing ability of the service provider according to S3. With the smart tag garbage and sensors on garbage vehicles, tracking and optimization of four garbage classifications could be designed. Routes planning could be redesigned dynamically based on the collected data. Besides, the information on the whole green chain could be transparent. A RFID tag on containers and one on the garbage vehicle allows for tracking recyclables and which homes exactly they came from. What's more important is that the device features GPS tracking to help optimize diver routes and fuel efficiency along with tilt monitoring which records when a bin gets picked up and put down. This system helps to collect the useful data about the garbage disposition results to make Key Performance Indicator (KPI) visualization. Besides, the message is effectively feedbacked to the corresponding users according to the unique QR code so that it improves the experience of participation, which forms a reward mechanism.

**Automatic sorting arm**

Corresponding to S3, data automation for the intelligent equipment give a hand in data automation which make efficient handling. An AI-based recycling robot can identify and garbage materials at super-human speeds from the "other classification". The reality is that many citizens throw garbage of uncertain types into other waste bins, which will decrease the efficiency and quality. A recycling robot equipped with AI can identify and separate materials at super-human speeds. It can detect packaging details such as logos and images—and then recognize them for sorting. This could help keep more recyclable materials out of other waste. It can solve the difficulties of other waste classification on recycling.

### 4.4.2 Visualization representation.

In order to evaluate the feasibility of the new service concept GC-SRPS in the context of smart city governance, we invited three industry experts to evaluate and discuss the above ideas, and they initially found the system structure practical. The score results represent in table 5. Moreover, there has been an improvement in the whole aspects, especially in the governance, technology and connectivity, as shown in Figure 3.

**Table 5.** The three experts' score results with mature model

| | Total | | | |
|---|---|---|---|---|
| | Standard Deviation | | Average | |
| | Traditional Service Trends | Waste management Trends | Traditional Service Trends | Waste management Trends |
| Governance | 0.58 | 0.58 | 1.67 | 4.33 |
| Technology | 1.00 | 0.58 | 2.00 | 4.33 |
| Connectivity | 1.00 | 0.58 | 2.00 | 4.67 |
| Value creation | 0.58 | 0.58 | 3.67 | 4.67 |
| Competence | 0.58 | 0.58 | 3.67 | 4.67 |

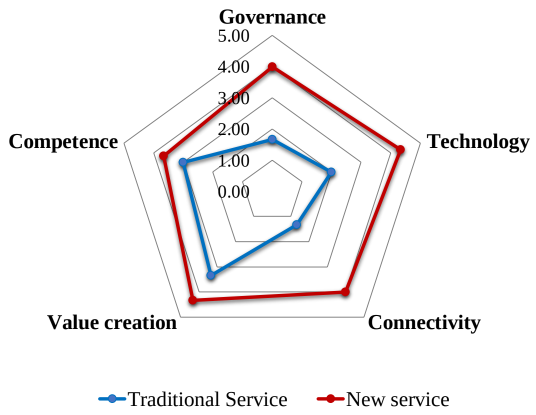


**Fig. 3.** The comparison radar chart of the previous and new service capability

## 4.5 Discussion

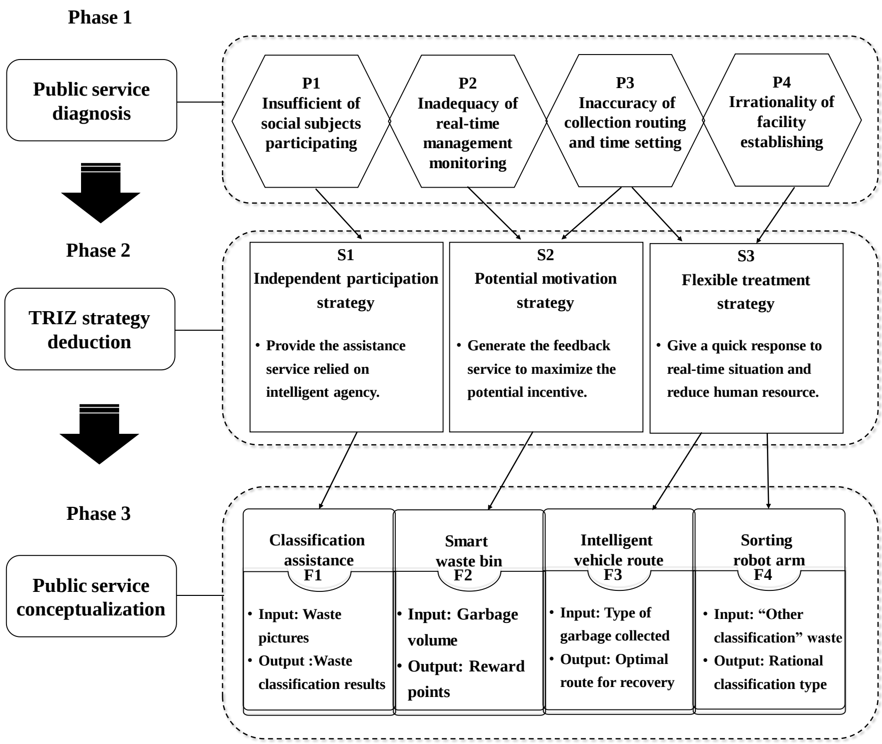


**Fig. 4.** The coherence figure for the outputs of each phase

The GC-SRPS system assists in smart city governance and gives a hand in the operation for four steps of waste management: classifying, taking out, delivering, and recycling.

The system realizes the data flow automation in the whole process and forms a perfect closed loop of feedback message. The information closed loop can complete the real-time monitoring, the scientific plan of garbage transportation route, and the reasonable arrangement of waste equipment. Meanwhile, this system will give users timely feedback on the benefits of garbage management and increase their social participation. GC-SRPS system employs the TRIZ evolution trend theory to perform industry analysis towards practical problems, as shown in the Fig. 3. The analysis results generate three TRIZ design strategies: “Independent participation strategy”, “Potential motivation strategy” and “Flexible treatment strategy”. These strategies are corresponding with the industry development laws and aiming at the development and design of intelligent garbage management systems to solve the identified problems in Xi’an city, which are defined as “the insufficient of social subjects participating”, “the inadequacy of real-time management monitoring”, “the inaccuracy of collection routing and time setting” and “the irrationality of facility establishing”. The above diagnosed problems will be explored in the further study using field research method. GC-SRPS system will improve the efficiency of waste treatment and promote industry development.

## 5 Conclusion

In conclusion, this research has the following contributions:

In academic aspects, the study fertilizes the application literature of TRIZ evolution trends in the public service domain under the sustainable development background. We attract more scholars to pay attention to the application of TRIZ evolution theory, rather than TRIZ matrix theory. This article also expands the TRIZ tool in the domain of public management and public service design to enrich its research methods. Moreover, the three-phase research framework could be extended in the design of other public service systems and provide the inspiration for the smart governance process. Finally, it provides an innovative project for intelligent waste management, and enriches the related literature.

In practical aspects, the context analysis and the real problem diagnosis are conducted in the case study. We propose a project with a practical reference value to solve the difficulties of waste management in Xi’an. The conceptualized system could also promote the industry development of the waste management and provide new ideas for urban governance.

## Appendix-TRIZ Evolution Trend for Waste management

(#1) Services Flexibility

| 37 evolutionary paths of TRIZ | Revision of paths after interviewing practical experts | Specific evolution process in waste management process |
|---|---|---|
| 1.Action Coordination | **Services Flexibility (#1)** | Recommended execution→Flexible execution→Mandatory execution |

(#2) Service Efficiency

| | | |
|---|---|---|
| 2.Rhythm Coordination | **Service Efficiency (#2)** | Tedious and repetitive tasks → Partial optimization of a single link → Global resource optimization |

(#3) Adaptability to the external environment

| | | |
|---|---|---|
| 3.Non-linearities | **Adaptability to the external environment (#3)** | Address environmental risks passively → Detect and quick response to environmental changes with flexibility |

(#4) Attitude towards user feedback

| | | |
|---|---|---|
| 6.Macro to Nano | **Attitude towards user feedback（#4）** | Passively manual deal with user's complaints → Actively listen to user's opinions → System-driven closed-loop service feedback. |

(#5) Customization degree

| | | |
|---|---|---|
| 10.Object Segmentation | **Customization degree (#5)** | Mass customization → Customization for a wide range target groups → Personalized customization based on big data precise portrait |

(#6) Increasing service interface

| | | |
|---|---|---|
| 14. Increasing Asymmetry | **Increasing service interface (#6)** | Partial participation at the end of the process → Full participation with user interface embedded |

(#7) User to interact with manufacturing

| | | |
|---|---|---|
| 15. Boundary breakdown | **User to interact with manufacturing (#7)** | Passively meet user needs → Actively interact with the demands → Independently participate in the waste treatment process |

(#8) Increase market publicity

| | | |
|---|---|---|
| 16.Geometric Evolution Line. | **Increase market publicity（#8）** | Waste treatment plant → Two publicity methods → Three publicity methods-Multiple publicity methods |

(#9) Resilience of order processing system

| | | |
|---|---|---|
| 19.Dynamization | **Resilience of order processing system (#9)** | Rigid mass recycling → Flexible order-based waste types → Personalized customization and flexible recycling |

(#10) Increase sales of additional products or services in waste treatment

| | | |
|---|---|---|
| 20. Mono-Bi-Poly Sim | **Increase sales of additional products or services in waste treatment (#10)** | Single-type waste management service development → Multi-angle coordination development → Comprehensive development |

(#11) Cross-domain product or service portfolio

| | | |
|---|---|---|
| 22. Mono-Bi-Poly Diff | **Cross-domain product or service portfolio (#11)** | Package of adjacent domain services → Integration of related domain services → Integration of multiple domain services |

(#12) Consumer demand level

| | | |
|---|---|---|
| 23. Nesting UP | **Consumer demand level (#12)** | Rigid demand → Flexible demand (S3) |

(#13) Virtualize consumption process

| | | |
|---|---|---|
| 24. Reduced damping | **Virtualize consumption process (#13)** | Physical channels → Direct recycling platforms → Precision treatment model |

(#14) Product perception

| | | |
|---|---|---|
| 25. Sense Interaction | **Product perception (#14)** | Service attribute performance → Elementary sensorial reflection → Advanced psychological reflection |

(#15) Add featuring services

| | | |
|---|---|---|
| 26. Color Interaction | **Add featuring services (#15)** | Low-cost service recommendation to improve explicit satisfaction → Targeted service recommendation to improve implicit satisfaction → Customized service recommendation to improve experience |

(#16) Service process transparency

| | | |
|---|---|---|
| 27. Increasing Transparency | **Service process transparency (#16)** | Opaque→ Partially Transparent → Fully Transparent |

(#17) Customer expectation

| | | |
|---|---|---|
| 29.Market Evolution | **Customer expectation (#17)** | Expectation met → Expectation maximization satisfied → Exceeding expectations |

(#18) Controllability

| | | |
|---|---|---|
| 34.Controllability | **Controllability (#18)** | Service quality inspection → Total service quality management → Online quality analysis and optimization of the entire industrial chain |

(#19) Decreasing human involvement

| | | |
|---|---|---|
| 35.Decreasing human involvement | **Decreasing human involvement (#19)** | Mass human participation → Semi-automated machine participation → Automation of data flow |

(#20) Cost reduction

| | | |
|---|---|---|
| 37.Reduce Energy Conv | **Cost reduction(#20)** | Cost control → Cost management → Cost refinement control → Optimal allocation of associated resources |

## Acknowledgement

This research was supported by the Xi'an Jiaotong University [grant number: 7121192301].

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