BLUECHAIN WHITEPAPER

A Case Study on the need for new high-tech infrastructure for the management of resources on China's Yangtze River Economic Belt (YREB), and a proposed Blockchain-based system for the efficient and environmentally aware handling of industrial water & waste resources.

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BYTOM

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Bluechain whitepaper: Multi-level digitization of real-world industrial waste & water resources, towards a better China

This whitepaper explores the Yangtze River Economic Belt (YREB) as China's largest continuous water production zone and ecosystem and identifies the current problematic situation on existing control schemes and methodology, leading to degradation and imbalances between Yangtze's multiple production zones.

It also proposes a newly designed system for Blockchain-based operations that can alleviate this problem, and help enforce environmental policies. Implementation of a high-tech management system is of strategic importance to China, as YREB represents a major fraction (42%) of its yearly GDP and its natural wealth in water. This project uses BYTOM infrastructure for Smart Contracts and Assets, and is submitted for the purposes of the Bytom Global Dev Competition, and is one of the first environmental resource large-scale management systems using Blockchain-tech to be designed.

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Bluechain is a blockchain-based system designed for the efficient and transparent management of industrial water & waste resources, in the framework of environmentally-aware advancement and growth. It uses Smart Contracts to model relations between its internal representations of the Government, Industries, Scientific Teams and Environmental Zones, and custom Assets to digitize the real-world resources transferred between them.

https://bluechain.tech

BYTOM is an intelligent, flexible and efficient digital asset layer protocol that supports the existence and transfer multi-byte custom assets and encompasses the infrastructure of asset Internet. Any peer-to-peer financial and asset applications and asset by institutions and individuals can be built on the Bytom blockchain[10].

https://bytom.io

Table of contents

“The development of the YREB must take into account the long-term interest of the whole Chinese nation. Indeed, the path of holistic ecological protection and green development along the Yangtze was emphasized by President Xi Jinping in a national YREB-focused meeting on 5th January 2016 in Chongqing. Only under this path could “clear waters” and “green mountains” bring significant ecological, economic and social benefits to sustain the vitality of the “mother river.” [3]

CHAPTER 1.

CASE STUDY: YANGTZE RIVER ECONOMIC BELT (YREB)

1.1. General Information

The human species, during its process of social & technological evolution, especially after the Industrial Revolution in the 19th century, gradually achieved exploitation and handling of all natural resources for the needs of human societies. Over the course of the 20th century, those needs shifted from local/societal to the shared needs of a globalized free market. Through this shift, severe gaps appeared mostly in the environmental sector which directly affect social structure, mainly in the developing, more disadvantaged industrial & agricultural regions. **China is the most noteworthy example of that and should be considered & analyzed as the most significant country in terms of population growth and development potentials.**

Water is an essential element for the existence of life, as it also is for the progress and the expansion of a nation itself. After 1950[9], China constructed a very powerful primary (exploitation of natural resources: agriculture, fisheries, mining etc.) and secondary (industries that take primary sector products as input and output an altered, finished, usable product or are involved in construction) production sector of economy. All those activities required substantial amounts of water resources and therefore, began discharging wastewater as the output of each operational activity. **This scaling-up process continues until today by following an exponential trend**. Many water courses, lakes & coastal waters are severely polluted as a result of agricultural, industrial and domestic discharges. China has very low water resources per capita (25% of the world average) and they are unevenly distributed. Among the 600 larger cities in China, 400 suffer from water shortages, and the pollution has severely degraded aquatic ecosystems as it poses **a major threat to them, as well as posing a major threat to human health and may limit economic growth[1]**. Ever-increasing economic development and human migration (e.g. impacts of climate change, land alternation etc.) can additionally stress water resources and water quality in a region.

However, wastewater discharged into surface waters represents a potentially reliable water *source*, if properly treated, but it can still convey hazardous (chemical & microbial) pollutants to cities and drinking water intakes located downstream [2].

1.2. Area of Study: Yangtze River Economic Belt (YREB)

The selection of Yangtze River Economic Belt (YREB) as the main area of our Case Study was based on the fact that it realistically demonstrates the vital importance of freshwater requirements in China's mainland regions. Yangtze is China's Golden Waterway, as it is the longest river in Asia and the third longest on the planet. It spans 6.300km from the glaciers on the Qinghai-Tiber Plateau across southwest, central and eastern China before emptying into Eastern China's coast in Shanghai (*Figure 1*). It drains 1/5th of the land area in the People's Republic of China (PRC) and its river basin is home to 1/3rd of China's population (584 million people) and supports more the 1/15th of the world's population [2]. <u>In 2014, the YREB provinces and municipalities generated ¥28,000,000,000,000 of Gross Domestic Product in China (GDP).</u>

This represents $4,033,000,000,000 (4 trillion US Dollars), nearly 42% of China's national GDP. Even as YREB remains one of the most productive regions worldwide, the importance of wastewater in the rivers stands ill-defined. Municipal wastewater produced in the Yangtze River basin increased by 41% between 1998 and 2014, from 2,580 m^3/s to 3,646 m^3/s.

On a higher scale, YREB represents 43% (30,800,000,000 metric tons) of China's total national wastewater discharge and 47% (or 323,000,000,000 m^3) of the national water use in 2014 [3].

1.3. Industrial & Social Status

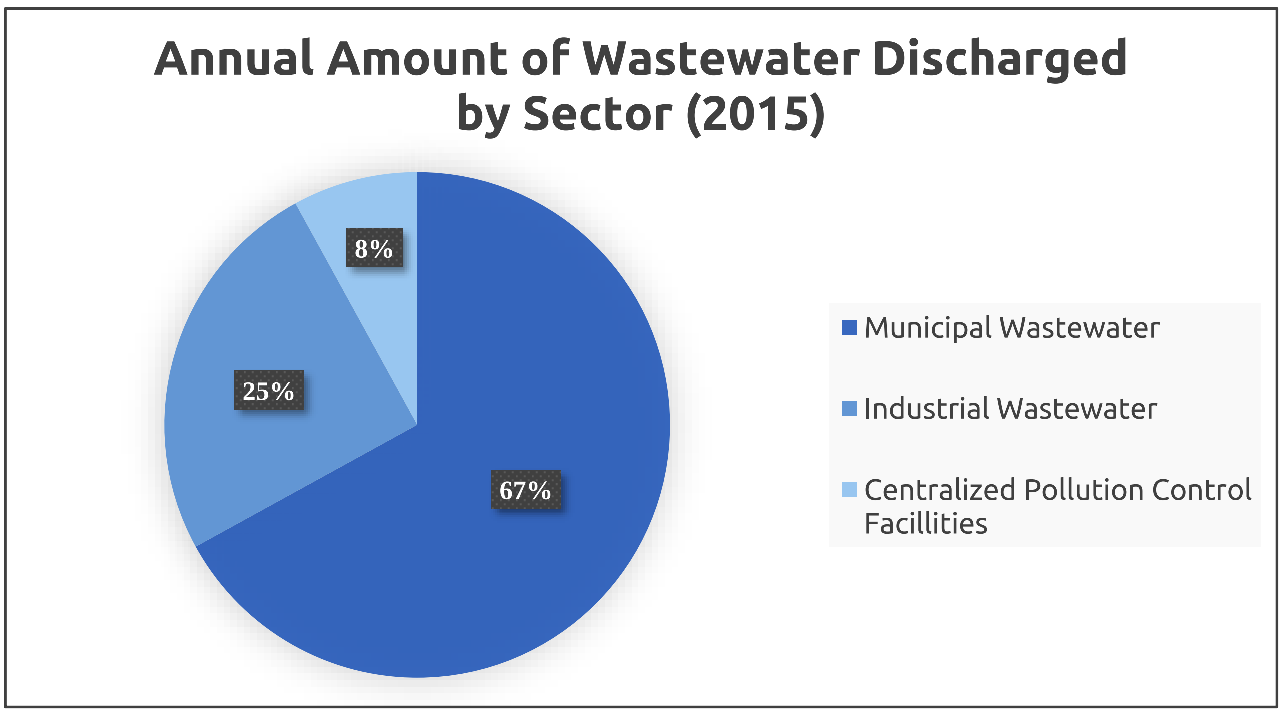
The region of YREB is essential for producing significant amounts of goods that are key to various industries as well as to food and energy security. Specifically, with the exception of agriculture (65% of the nation's rice cultivation takes place in the region), the numerous industries that are located in the Yangtze region carry out fundamental operations for China's financial viability & sustainability [3], such as:

- Energy (40% of China's total production of electricity & 73% of China's total production of hydropower takes place in the region)
- Construction Materials (cement – 48%, primary plastic – 40% and crude steel – 35%)
- Clothing/Fashion (81% of China's total production of chemical fibers & 59% of China's total production of cloth).

According to the "Announcement of the Urban Wastewater Treatment Plants list in 2014" (the 35th announcement of the

MEP, China 2015) there exist **4,436 Waste-Water Treatments Plants (WWTPs)** in service, with treatment capacity of 171,000,000 m^3/day[5]. In 2015 around 74,000,000,000 tons of wastewater were discharged by China's domestic, industrial & other commercial users. Of this amount, roughly 67% was Municipal wastewater, 25% was Industrial wastewater and 8% came from other centralized pollution facilities (*Graph 1*). One significant observation is the fact that more wastewater is discharged by provinces along China's coastal and YREB zones than by inland provinces.

At the end of 2015, the installed base of industrial wastewater treatment facilities in China is around 83,227, with a daily treatment capacity of 247 million tons. But in practice, despite having an annual treatment capacity of around 90 billion tons, the actual amount of wastewater treated in 2015 was only roughly 44 billion tons - **a utilization rate of below 50%**[4].



Graph 1: *Annual (2015) amount of wastewater discharged by treatment sector in China (China's Statistical Yearbook on the Environment 2016, modified by G. Vagenas - 2018)* [4].

The metallurgy, chemical and paper manufacturing industries are 3 of the top spenders on wastewater treatment in China. On average, the expenditure for treating 1 ton of wastewater in the industrial sector is about RMB 1.50. As a result, the total cost of industrial wastewater treatment in 2015 was, on average, **¥66,000,000,000 RMB** or **$9,500,000,000 US Dollars** [4].

The YREB is divided in three sub-regions: The **Upper**, **Middle** and **Delta (Lower)** Yangtze reaches (*Figure 1*)[11].

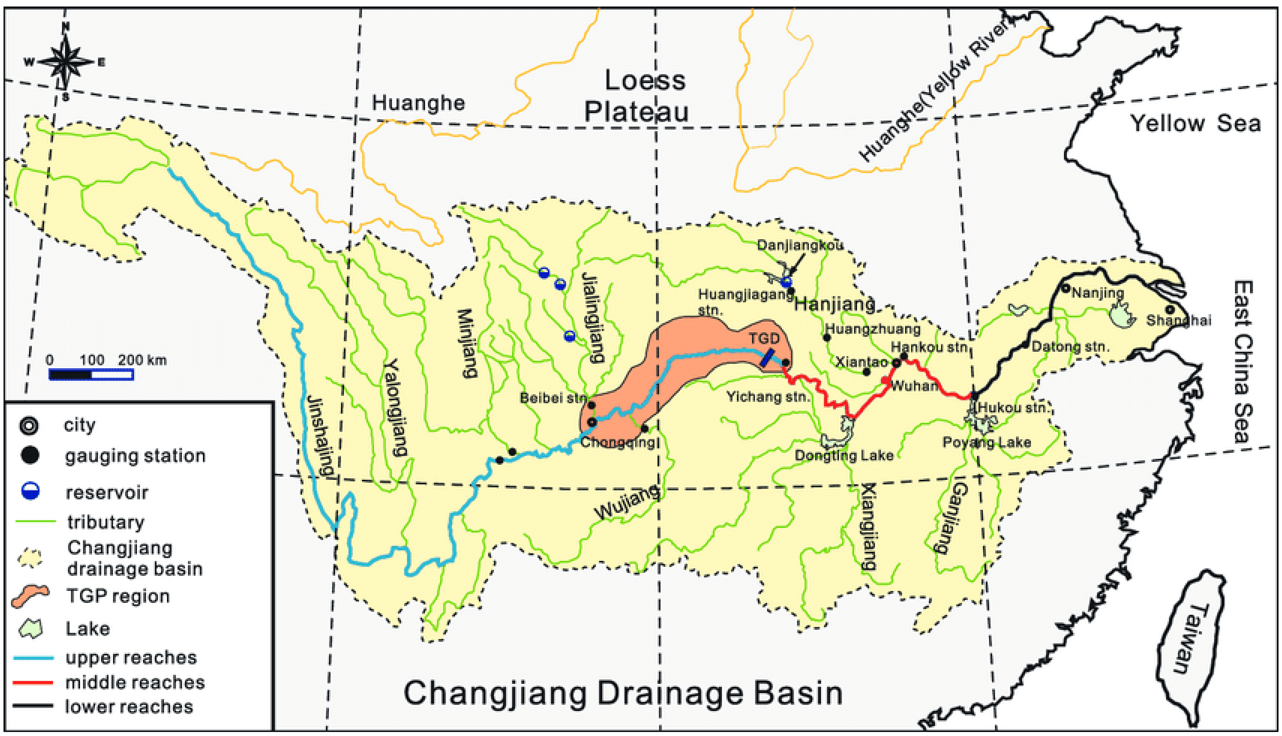
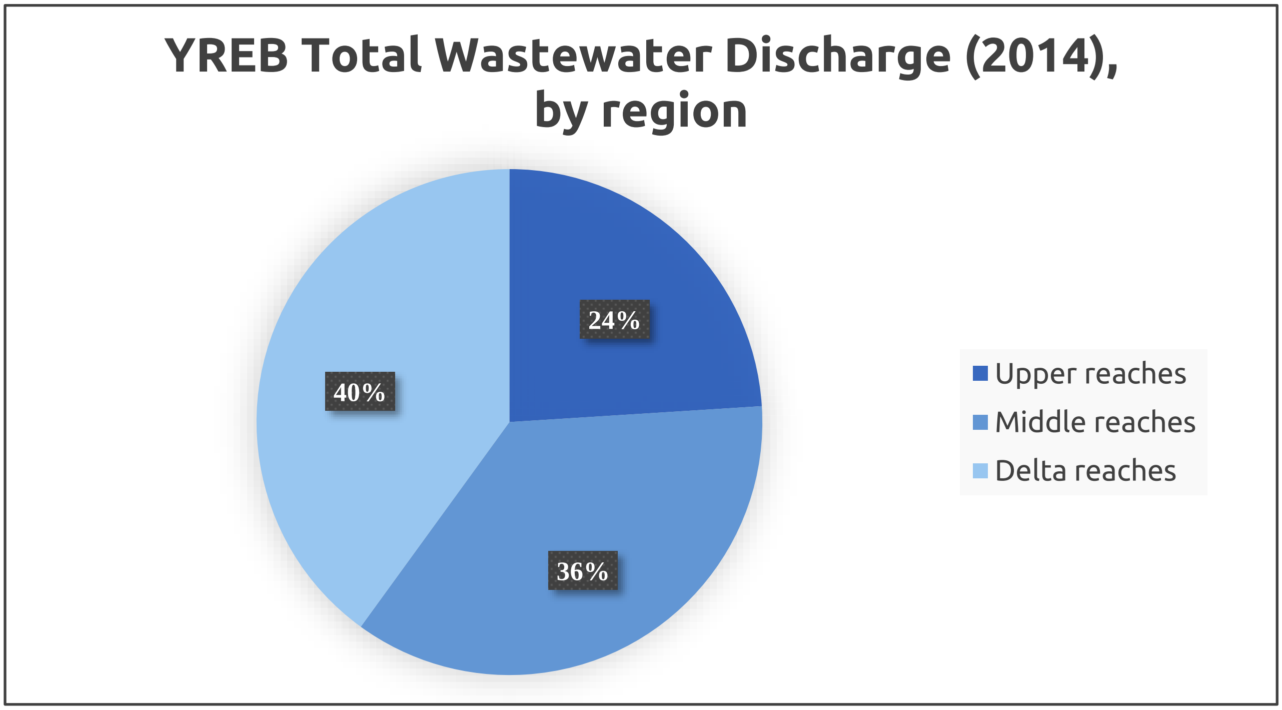


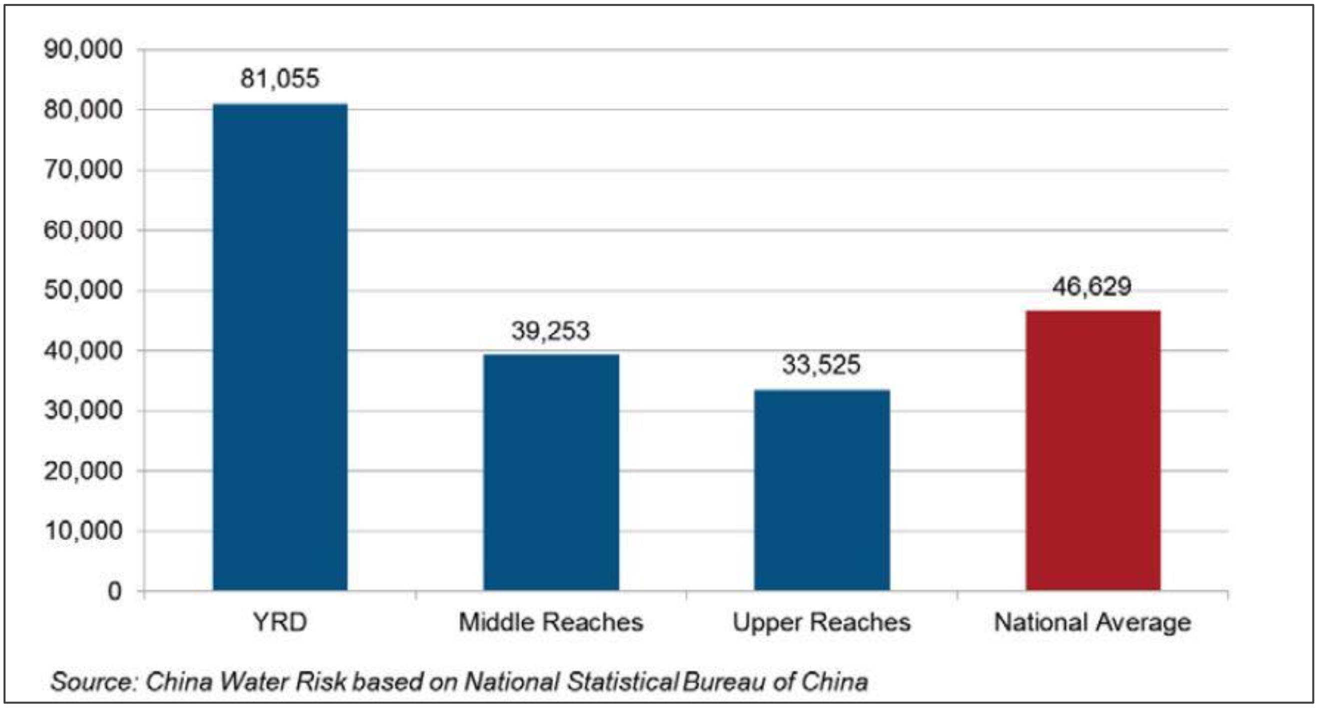
Figure 1: *Map of the Changjiang (Yangtze) River: TGD, Three Gorges Dam; TGP, Three Gorges Project*[11].

The ratios of the total amount of wastewater discharged per sub-region are available below, in *Graph 2*[1]:



Graph 2: *The ratios of annual (2014) amount of wastewater discharged in the YREB region (modified by G. Vagenas - 2018)*[3].

The Delta reaches region is the richest, with a GDP of ¥81,055 RMB per capita, more than twice that of the Middle and Upper Reaches (*Graph 3*). The difference of economic development in the three regions has led to dispersed trends in water pollution and water use, as was noted previously.

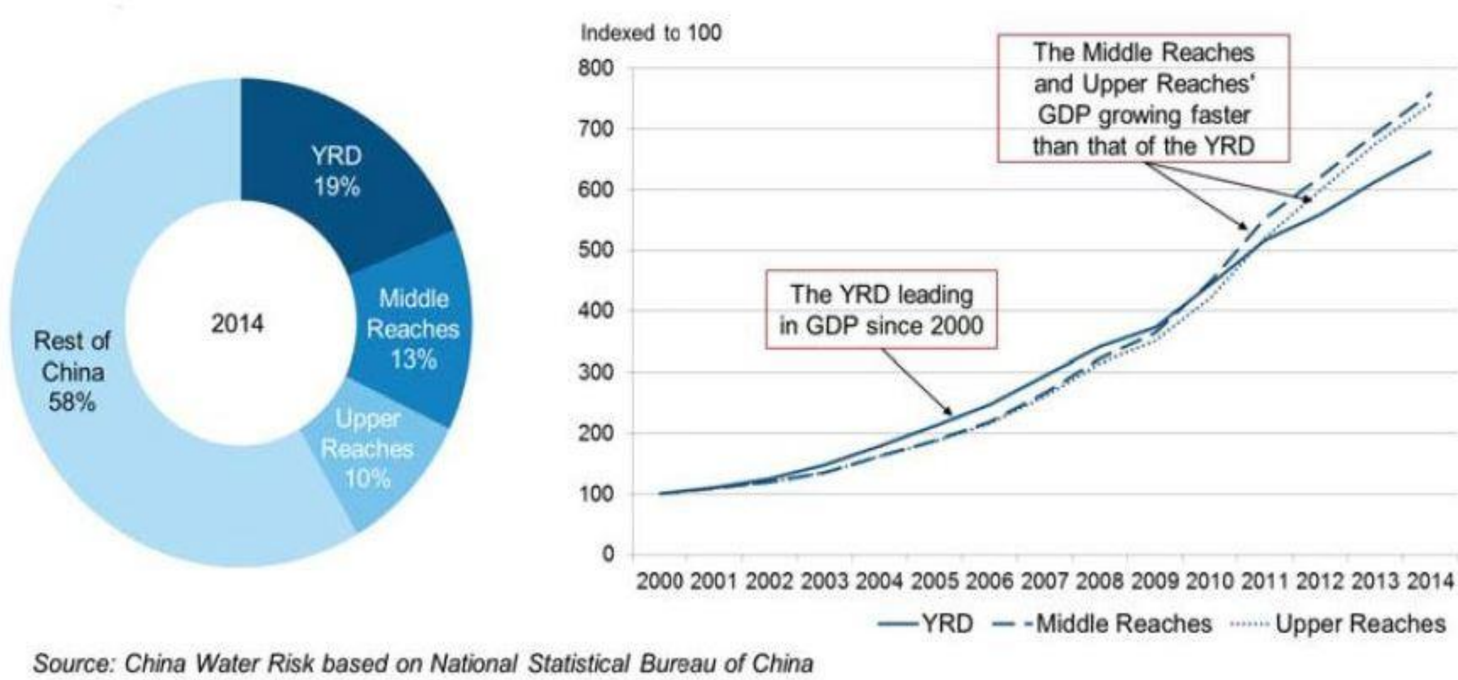


Graph 3: *The Yangtze River Economic Belt (YREB) vs. National Average on 2014's GDP (Currency: RMB) per capita* [3].

By considering *Graph 4*, the **development growth rate** of the Middle and Upper reaches is higher when compared to the YDR region. At the same time, rapid rise of wastewater discharge took place in the same region.
Since the agricultural and industrial sectors are both significant contributors to pollution, this explains the continuous rise in wastewater discharges in those upstream regions.

From an economic point of view, it is logical to move industries inland, where production cost is relatively lower. Inland economies and provinces can also develop, closing the rural/urban and inland/coastal income gap[4]. Even as the aquatic and terrestrial ecosystems are continuous, the industrial layer is scattered and unevenly distributed.
Subsequently, it is only a matter of time that financial inequities will occur in the different societies of each location. As a result of the previous, a lack of infrastructure and technical means will lead

to social degradation and low quality of life. Based on the findings of our case study, in 2015 only 11,4% of China’s villages had access to wastewater treatment facilities. Apart from the villages, only about 7-25% of China’s towns & townships had these facilities [2].
Combining the lack of water resource management systems and the dysfunctionality observed in the State’s decision centers, high unemployment rates and low social security payments make it even more difficult for citizens to afford tap water, an essential human need[6]. Continuing, **the necessity of controlling and distributing natural resources in a rational and sustainable level is of utmost importance.**



Graph 4: *The YRD leads the YREB in GDP but upstream growth is rising faster than YRD-YREB region's GDP and historical trends[3].*

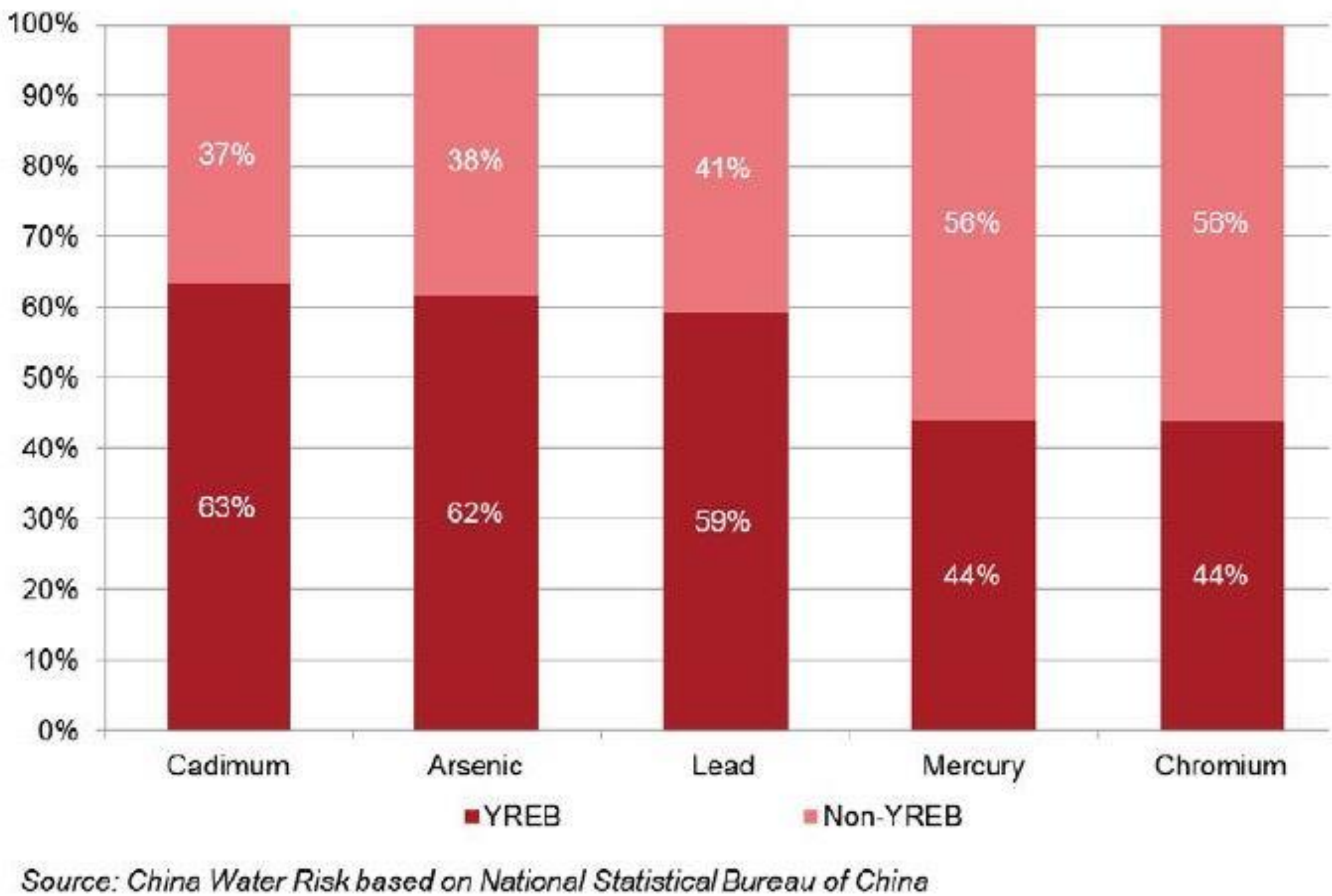
1.4. Environmental Status

Before the 1990s, sewage was mostly used to fertilize crops in rural areas, but currently all of it is dumped directly into rivers, along with wastewater, resulting in E. coli levels exceeding normal standards. Additionally, incidents of broken pipes & leaks in the wastewater network in many districts resulted in severe environmental pollution & contamination events[6]. Therefore, water quality becomes questionable and raises concerns towards public health issues. **There is a pressing need for a dependent, well-designed platform that can optimally gather and control data, to facilitate the clear and transparent process of waste and water resource management.**

Apart from the health risk, the gap of knowledge and real-world experience has led to system failures that escalated the negative impacts of random environmental phenomena.
For example, in the report "An Investigation into Wastewater Treatment in the Three Gorges Reservoir Basins" (A Probe International Study, 2013), it is stated that the Three Gorges Dam has robbed the Yangtze River of its ability to purify itself. The main idea is that the 40 WWTPs in Chongqing (one of the main regions) reduced the water flow of rivers, resulting in a general decrease of water rate flow[6]. During waste material water flow, heavy metals are initially dissolved in the water, then *adsorbed* and finally accumulated on the bottom sediments, acting as a basin[12].
Consequently, the numerous types of pollutants in the water cannot be diluted or flushed as efficiently as before, forcing ecosystems to eutrophication or large scale extreme pollution events in specific tributaries [6].

Those cascade effects have an impact not only on the water resources directly, but also on the general biodiversity of an aquatic ecosystem. By considering the continuity of a river's flow, mainland pollution incidents, without proper treatment, will indubitably reach Yangtze's river delta (one of the most productive systems in China) and finally damage the Pacific Ocean's coastal and marine zones.

As referring to industrial-scale operations, YREB as a whole accounts for 43% of China's total wastewater discharge (2014) and it has disproportionately high heavy metal discharges, according to the national quotation per area, especially in: Cadmium (63%), Arsenic (62%), Lead (59%) and other metals in comparison with other non-YREB regions in China (*Graph 5*) [3].



Graph 5: *YREB heavy metal emissions in wastewater.*

Disproportionately high in the YREB region in 2014 than non-YREB[3].

The cities of Hunan and Hubei account for the lion's share of YREB's discharge in Arsenic, Cadmium and Lead at 71%, 69% and 63%, respectively. These levels are worrisome as both regions are important grain producing areas.
However, such heavy metal industrial pollution could flow downstream through the river and pose a substantial threat to the safety of China's key food staples. Additionally, there are food security implications given the magnitude of agricultural production along the Yangtze River and limited arable land across the country [3].

Therefore, a holistic approach of Yangtze as the central and vital environmental artery of China is an essential step in sustainable, blue growth development, serving the needs of society, serving the needs of the market.

太原重工

CHAPTER 2.

BLUECHAIN: A NEW ERA OF MANAGEMENT

Powered by the BYTOM Blockchain

2.1. A brief introduction on Bluechain

Bluechain utilizes Smart Contracts to control and maintain an ecosystem of transferrable Assets that represents a close digital imprint of the real-world waste & water resource management sector.

Relationships of authority, governance and production are designed into the system, so as to help existing industries automate their resource request and waste disposal operations on the blockchain and provide the tools for evaluators to easily detect problems and discrepancies, promoting sustainable economic growth and lawful, environmentally-aware practices.

2.2. Bluechain's edge

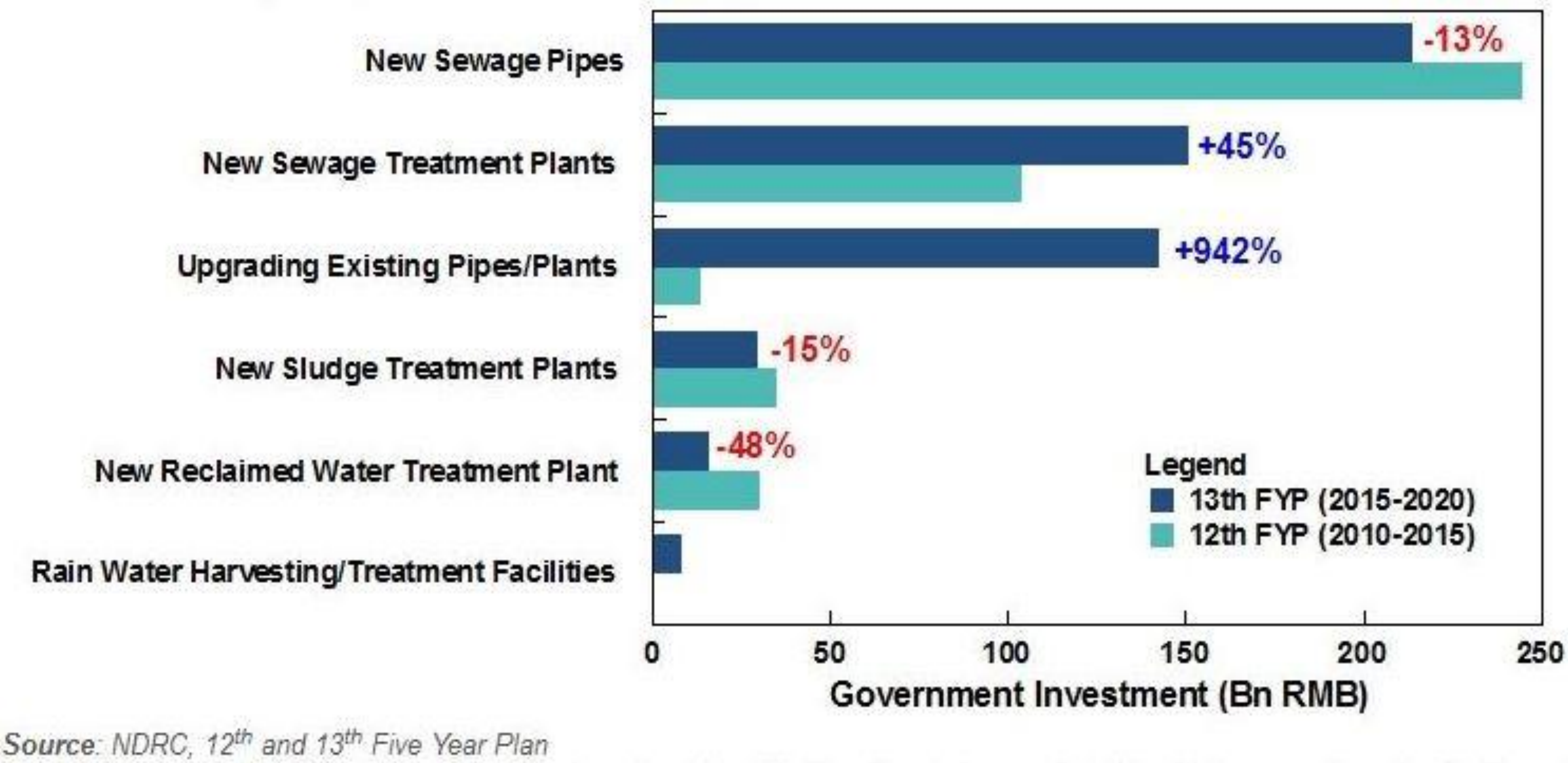
It is evident that water is important and essential for economic development. As China grows, the demand for water will rise definitively, adding pressure to its already limited natural resources[1]. Following China's ever-growing shift towards environmental protection, demand for wastewater treatment facilities has increased across all sectors. The demand among industrial users has also been strong due to the more stringent environmental regulations and restrictions[4].

The most important factors that amplify the current problematic situation are the constantly growing demand in combination with the limited available resources.

Considering the availability of substantial funds proposed for improvements in the wastewater treatment sector, **innovative high-tech optimization systems are expected to be the industry's most significant driving force in the near future[4]**.
Furthermore, the ecological recovery of aquatic ecosystems in China through *Bluechain*'s implementation as well as the upgrade of environmental protection strategies in poverty stricken areas that comes with it is fully compatible with China's Environment Authority's current goals[8].

In regard to the available funding in this sector, as an important factor that promotes innovation, the Chinese State during the 13th Five Year Plan (2015-2020) aims to invest ¥559,000,000,000 RMB ($80,517,409,000 USD) on its water industry. This national-level fund accounts for only 10-30% of the total financial supply in the sector.

An inner look at the total fund allotment (*Graph 6*) reveals that 25% of the budget is, for the first time, directed towards "Upgrading Existing Pipes/Plants" in contrast with the 12th FYP's (2010-2015) significantly smaller margin. Furthermore, the majority of the funds are intended towards new sewage treatment plants and new sewage pipe networks[4].
The general concept behind this investment's distribution is that the Chinese Government seeks new technologies to optimize and upgrade its existing treatment process and networks, keeping them innovative, robust, durable and efficient.
This is where blue growth can be achieved in a framework of a long-lasting economy and industrial development plan through already available resources.



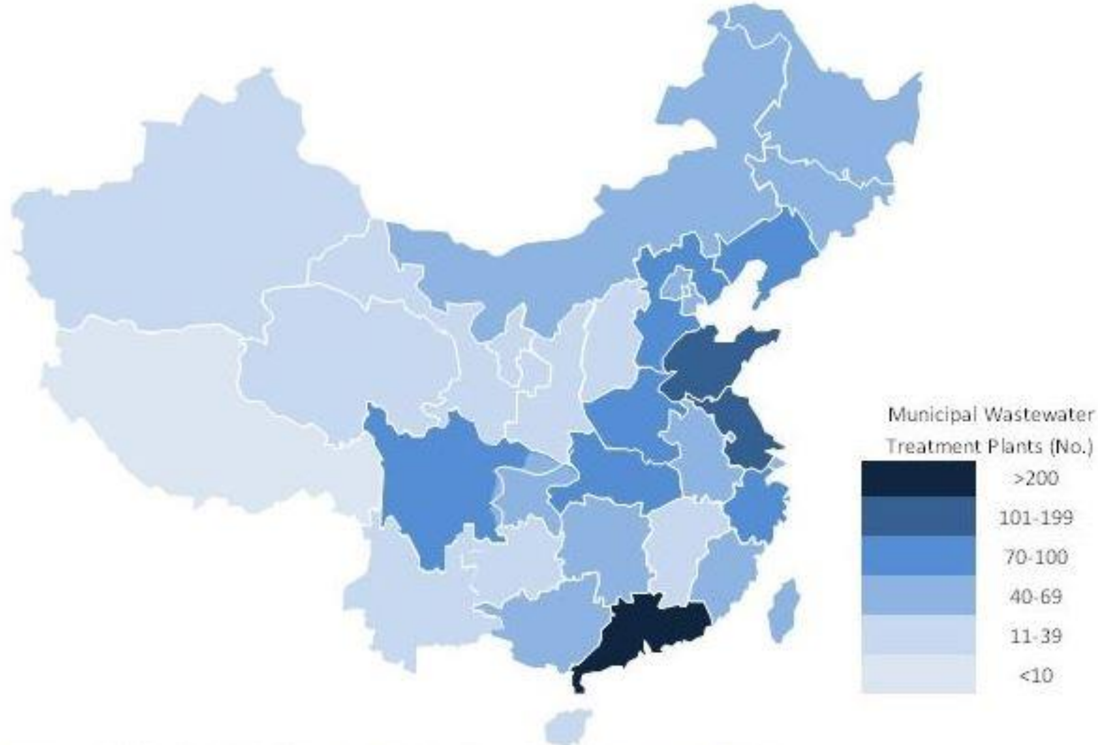
***Graph 6:** Fiscal national level funding investment by category on China's wastewater treatment (12th vs 13th Five Year Plan)[4].*

Bluechain's tech resolves this problem by introducing a new, optimized system of environmental and industrial resource distribution management, using the BYTOM Blockchain architecture, thus elevating an existing production sector into the era of blockchain-based organization.

The cornerstones of *Bluechain*'s philosophy are: **Security, Sustainability, Development, and Innovation (*SSID*)**. This *SSID* direction that we are proposing dynamically adapts to situations and overcomes obstacles as they appear in the chain of natural resource control process (in our Case Study, YREB's wastewater treatment procedures).
Our project's major advantage is that it is built on the fundamental disciplines of decentralized hierarchical decision making (*Chapter 2.4*).

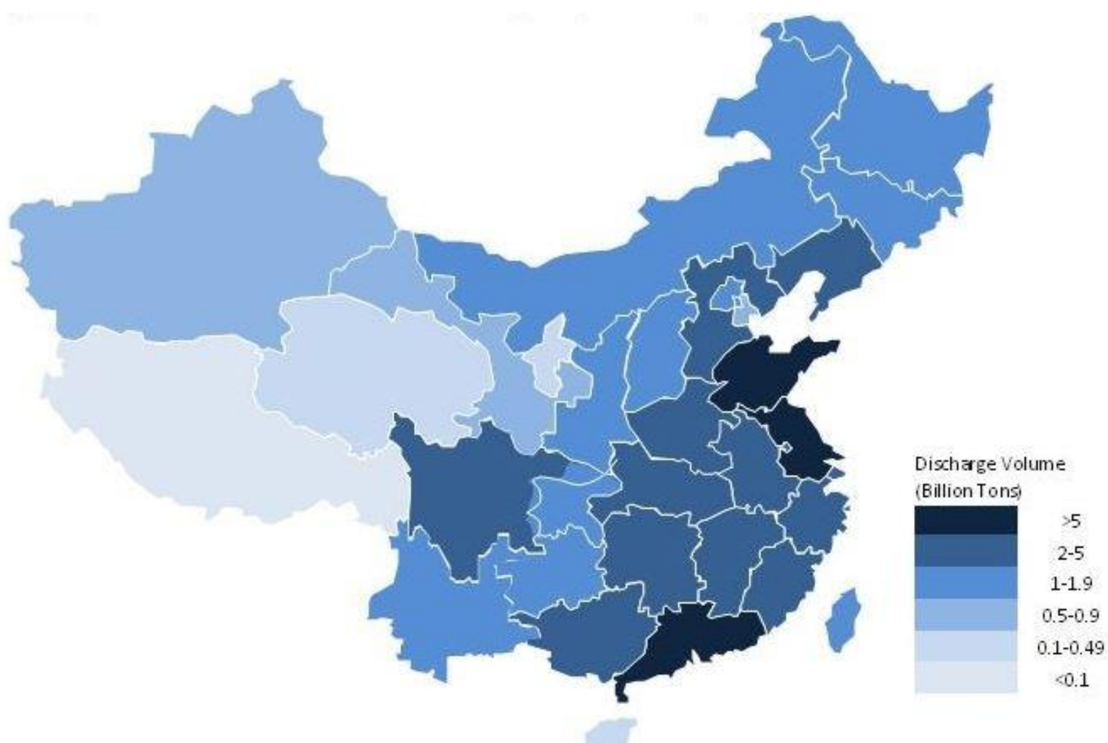
As mentioned in *Chapter 1.3*, the bulk of China's wastewater is generated by the household (domestic) sector and as a result, the rising demand for domestic wastewater treatment facilities constitutes a significant portion of the market[4].
One of the main concepts that need to be up for consideration is the significant gap in treated and untreated wastewater between the YREB treatment regions. The infrastructure of WWTPs in the two upstream regions (Upper and Middl) is still lagging behind. This is especially true in the Upper reaches, where the urban daily sewage capacity was only 11,600,000 m^3/day, a number that corresponds to 50% of the Middle reaches and to the 33% of YRD's daily sewage capacity [3].

In Graph 7, a pattern is discernable: **Urban Municipal WWTPs, by Province (2015) are not at all equivalent with *Graph 8*, which visualizes the distribution of the Annual Amount of Wastewater Discharged, by Province (2015**).
Especially in the upstream regions, in the mainland areas further away from the YRD, the correlation between the patterns of *Graph 7* & *Graph 8* is gradually disappearing. There exists a greater need of WWTPs near the YRD region, due to higher scale of industrial and agricultural operations, however this does not override the solid argument on the existence of a continuum in natural ecosystems.
Environmental conservation **should and must** take place by evaluating all the different ecosystem parameters, and reduce/balance, whenever possible, one-dimensional investments towards only-locally profitable human activities and regions.
If this management strategy can be enforced with a proper data and effective socio-economical backbone, for example by using specialized systems like *Bluechain* (an *SSID* oriented system), efficient avoidance of accumulated environmental cascade effects and extreme events can be achieved.



Source: GCiS, China's Statistical Yearbook on the Environmental 2016

Graph 7: *Number of Urban Municipal Wastewater Treatment Plants by province in China (2015)[4].*

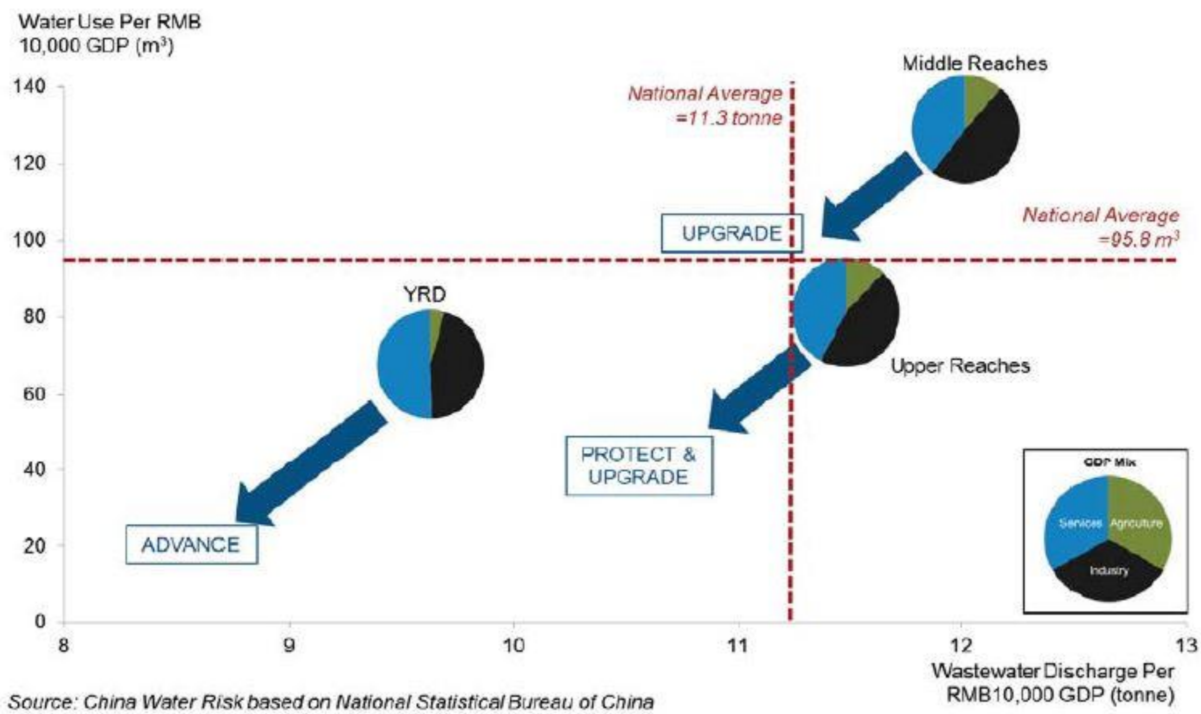


Source: GCiS, China's Statistical Yearbook on the Environment 2016

Graph 8: *Annual amount of wastewater discharged by province in China (2015)[4].*

In summary, it is important that a multi-dimensional re-arrangement process and analysis must take place, so that inter & intra competition in China's industrial market can increase, and all possible shortcomings and gaps in the chain process of wastewater treatment can be resolved, on a national level.
Bluechain, via its entity-oriented and simplified, decentralized design (*Chapter 2.4*) allows for open-access information gathering and implements the multiple levels of authority and control for participants (The Government, Industries, the Scientific Community, Environmental Areas), towards blue, sustainable growth.
This is the only way of representing different entities in the system, so that economic development can take place, with respect to each region's individual, unique characteristics.

Therefore, through *Bluechain*'s approach, it will be easier to monitor and manage the three YREB regions and succeed at meeting the required goal of the 13th Five Year Plan on each region (*Graph 9*).



Graph 9: *2014 YREB Regions - Per RMB 10,000 GDP water use & water discharge*[3].

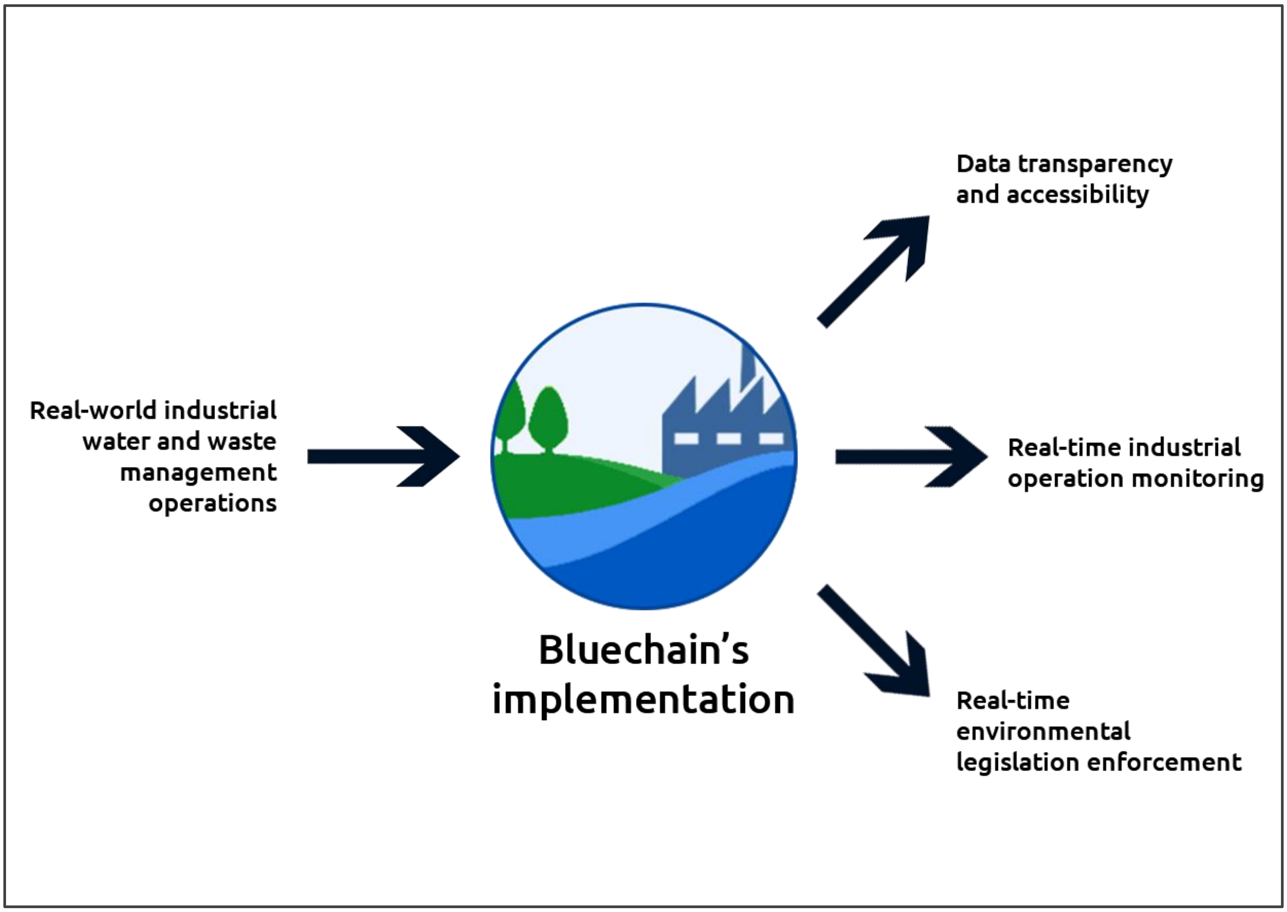
2.3. Bluechain’s goals

The four structural domains of *Bluechain* are:

- the **Government** (an administrative body, regulates transfer of assets where needed)
- the **Industrial sector** (requests and handles natural resource assets, gets rewarded for good practices)
- the **Scientific community** (an academic body, collects data on the ecosystem and either approves transactions or reports to the Government about the system’s health)
- the **Environmental Areas** (represent real-world locations and their capacity in natural resources and waste).

The interactions (transactions) between those four Objects in *Bluechain’s SSID* oriented ecosystem, gives the advantages of (*Graph 10*):

- Open-access data on environmental exploitation. Additionally, the entire chain of actions that led to a transfer of natural assets by an industry or WWTP (request, control, approval, issuing) is visible and open to analysis.
- Real-time monitoring on industrial operations.
- Real-time implementation of environmental legislation by dynamically approving or rejecting asset transactions based on environmental data, on any objection level.



Graph 10: *Advantages gained through Bluechain's platform.*

Thus, each domain sector (Object of our ecosystem) will gain individual advantages & development potentials while also being introduced to additional profit methods, by being able to multi-dimensionally interact with its ecosystem. These profit ways do not only concern the socio-economic stratum (public & private sectors) but also the represented environmental zones.

The **Government/Administrative sector**, through *Bluechain*'s implementation, will achieve:

• Advanced & Upgraded Operational Activity Monitoring

Real-time monitoring optimizes the control methods by allowing a closer look at every domain's inner process and transactions, in an ecosystem of transparent industrial activities.

• Advanced & Upgraded Environmental Conservation Enforcement

By actively taking part in the Smart Contract's approval or rejection process, either by the Government or the Scientific Community, enforcement of environmental conservation laws is organically achieved. A more efficient and risk-averse method of handling Public funds arises, intended for environmental protection.

• In-vivo construction of spatio-temporal data-series through *Bluechain*'s native operations

The following advantage naturally derives from the systems normal operation: Transactions of assets carry a timestamp and *sender/receiver* that is represented spatially in our ecosystem (an Industry, or an Environmental Zone). Therefore, spatio-temporal data-series are natively produced through day-to-day operations, analysis and interpretation of which can optimize and identify trends on environmental phenomena. Each transaction can be abstracted to an experiment, a circular procedure of inputs*: waste disposal, water use, sampling* and outputs: *environmental impact*. As a result, a gradual database of experimental observations is built, on which Information Retrieval methods can be applied to, to produce knowledge and help with future decisions.

If database size begins to exceed normal sizes and migrates into Big Data territory, we propose an Artificial Intelligence (A.I.) decision-making system for analysis and wisdom production, based on the data (*Chapter 3.4*).

• Water Quality & Public Health Security
Through the above operations, the public's concerns on health issues and water quality will be eased due to the management of waste resources. Not only will the total amount of treated water be increased, but there is also going to be a gradual elimination of environmental pollution events caused by poorly maintained networks, as every facility will be constantly supervised on its operational activities, and can have penalties imposed upon it in case of misconduct.

• Water Use Reduction
A status of better management leads to more efficient natural resource exploitation. *Bluechain* is designed in parallel with China's strategy in the 13th FYP to "Target reduction in water-use per unit of GDP by 23% by 2020 and also reduction in COD (Carbon Oxygen Demand) & NH discharge by 10% each". Moreover, with our *SSID*-oriented design we aim to achieve "more eco-red lines and tech policy innovations [...] to build a Beautiful China 2020, a social & economic vision - continued structural revamp in governance & economic mix expected"[7].

• Upgraded Social Welfare
Our project seeks to stimulate economic growth not only in the private market sector, but also in society itself, especially the more disadvantaged regions. BlueCoin represents a unique reward asset in our ecosystem, provided by the Government sector towards Industries in respect to their efficiency in wastewater treatment, data transparency and other good practices. As an indirect result of the BlueCoin reward (*Chapter 3.2*), poorer regions with higher unemployment rates and low social security payments can benefit by discounted tap water fees[6] . BlueCoin rewards can also act as an investment motive for the private sector, to upgrade an area's social status.

The **Industrial sector**, through *Bluechain*'s implementation, will achieve:

• Investment Risk Reduction

Through analysis of *Bluechain*'s transactions, trends will emerge showing the most profitable investment pathways. In the work of "COD Discharge Limits for Urban Wastewater Treatment Plants in China Based on Statistical methods"[5], the three factors that showed significant correlation with COD discharge conditions were: geographic location, treatment process, and the ratio of treated wastewater in industries. The last factor was proposed as the most worthy of attention, therefore BlueCoin focuses on maximizing treatment process efficiency, so as to promote blue growth (market and social profit).

• Industrial Cost Reduction

Through the same transactions as mentioned above, open-access data in wastewater treatment provide a method for real-time forecasting, the results of which can be used to minimize energy/transportation costs for wastewater. Additionally, through this analysis, the most adaptive and competitive industrial facilities can be identified and rewarded. The Chinese market can shift, for the first time, towards a global free market, away from the current crude, profit-based competition towards a more sustainable and development-oriented one.

• Opportunities for development in cutting-edge, emerging technologies and investments

The development environment of Blockchain technologies is constantly changing, evolving, and by using *Bluechain* and BYTOM, an Industry is placed on the technological bleeding-edge of innovation. Opportunities, of drastically improved operational speeds and government investments are thus presented to users of the *Bluechain* system, furthering the Industry itself as well as China's national technological infrastructure as a whole.

• Decreased Environmental Penalties & Sanctions
Bluechain's platform promotes legality, transparency and respect to existing environmental legislation, as honest and efficient waste treatment industries are rewarded for good practices (through BlueCoin, *Chapter 3.2*), and therefore minimize costs due to environmental penalties imposed by the Government. Cleaner operations mean more profit.

• Discovery Of New Profitable Investment Areas
Through collaboration with Scientific Teams through *Bluechain*'s platform, industries are directed towards resistant and unmolested environmental ecosystems, thus balancing the load and impact of disposal operations, and potentially revealing new investment areas in previously unused regions.

The **Scientific Community**, through *Bluechain*'s implementation, will achieve:

• Additional revenue streams and funding towards discovering new pathways for environmental resource management

Data streams are available to anyone, in *Bluechain*. The data can be therefore used by any of the Scientific Teams involved in the platform to unveil and discover new mechanisms, new strategies for waste disposal and environmental resource management, something that was impossible previously due to the individual gaps of knowledge between different research teams in the sector.

These vacuums of knowledge can be easily covered by shared information between scientific teams, leading to the more efficient utilization of available funding and the investment risk reduction for outside parties in the Environmental Research sector.

• Expansion & Upgrade of Current Environmental Data-series

Existing data-series on environmental variables and occurrences get richer by adding-in the results of applied analysis on *Bluechain* transactions, which representing disposal and resource-use operations. Additionally, by abstracting collections of transactions to experiments, existing experiment databases get collectively larger and more fit to application of academic Information Retrieval and Data Analysis methods.

• Rapid Real-time Environmental Restrictions Enforcement

Scientific teams actively take part of the ecosystem, as the first and last control mechanism of all potentially damaging operations. Therefore, by enforcing their control on the systems, environmental restrictions can easily and effectively be enforced on Industrial users, should the analyzed data show discrepancies or should the proposed disposal/use operation would damage an ecosystem irreparably.

The **Ecosystem/Network of Environmental Areas**, through *Bluechain*’s implementation, will achieve:

• Identification and restoration of highly-degraded, endangered aquatic environments

Analysis of *Bluechain* transaction data quickly yields those environmental zones that received the most waste and/or had the most water taken out of them for industrial use.

These transactions can then be used to produce environmental data indices, reflecting the current situation on the network of ecosystems. By re-balancing this weighted network of environmental zones, measures can be taken towards temporarily easing exploitation and shifting industries away from the more damaged ecosystems, either by more efficient business strategies or enforcement of political decisions.

• Dynamic redirection of Industries towards new Investment Areas, easing the pressure on already-overstressed aquatic zones

Constant live-data monitoring on the Environmental Zones by the Scientific community shifts the Industries’ interest towards the most resistant, underused zones which offer higher BlueCoin rewards, leaving room for any overstressed environmental areas to rest and replenish their resources.

• Sustainable natural resource exploitation

Bluechain strives to dynamically counterbalance the ecosystems it manages, and to prevent outliers. Exploitation of natural resources therefore remains within strict limits, as directed by National legal frameworks for sustainability and respect towards Human Quality of Life.

• Biodiversity protection through effective legislation enforcement

Considering the numerous cascade interactions between water trophic levels, terrestrial & aquatic ecosystems, human societies and their relationship with nature as well as most importantly, the current gap of knowledge in ecosystem mechanisms, *Bluechain* can help fill-in those gaps and actively aid in better research error-prediction and accuracy. As a result, a clean-running managing environment is achieved in ecologically-sensitive industrial regions, such as China’s YREB.

2.4 Bluechain's Design & Code

Note that our code and work is, in its entirety, open-source and available freely, under the MIT License.
It is hosted on our GitHub repo[13]. We have detailed documentation on its functionality, and graphs of operational flow as needed.
We have also created a Starting Developer's Guide, on how to create BYTOM custom Assets and write BYTOM Smart Contracts, available on our GitHub's Wiki page[14].
The main website for our project is https://bluechain.tech

2.4.1. Structure

Bluechain uses MultiSig wallets for its four (4) different subsectors to store and transfer Assets, and connects the interactions between them with Smart Contracts. Everything is implemented on the BYTOM Blockchain.

MultiSig wallets are used to represent *multiple sector approval* for actions, so that no one sector by itself is responsible for a movement of Assets on the system (other than some processes initialized by the Government, which has maximum authority and needs to remain impartial). BYTOM implements an M of N signature system for MultiSig wallets, meaning M Signatures of N users are needed for the Wallet or Smart Contract to unlock.

2.4.2. Assets

Bluechain keeps track and uses 5 different custom Assets:

1. WasteToken
2. WaterToken
3. WasteCapacityToken
4. WaterCapacityToken
5. BlueCoin

1. WasteToken

WasteToken represents raw waste tonnage in our system, the result of industrial output. It is initially issued by the Government, and transferred to Industries according to their operational scale as maximum tonnage of waste they're allowed, according to environmental legislation, to dispose of on any ecosystem(s).
WasteTokens (and WaterTokens, described later) of specific amounts are therefore the only operational assets Industries use, to represent their internal production process. They transfer them to environments to signify disposal operations, after the approval of delegated Scientific Teams (that deem the amount and type of waste fit to be transferred to a specific environmental zone). This is the first type of digitized resource transfer performed in our system.
Any leftover WasteTokens in industrial wallets, at the end of an economic term (monthly or yearly) also represent how efficient the production process of an Industry was, when subtracted from the initial amount given to them by the Government on term-start. The more leftover WasteTokens, the less waste an industry actually disposed of in environmental zones.
Leftover WasteTokens are transferred back to the Government to claim BlueCoin rewards, along with varying amounts of WaterCapacityTokens and WasteCapacityTokens - which help calculate how "clean" the industry's operation was, and all together weigh-in in the final reward amount.

`Testnet AssetID:`
`16d46f9d952661fcf4f3744cfeba752c08a3cb4f611a52ea7a8c557facaf4e7d`

2. WaterToken

WaterToken represents fresh-water tonnage, to be used as input in industrial operations. It is initially issued by any of the Scientific Teams and, with the approval of at least one other team (or the Government itself, as the Government operates a small scientific crew), transferred towards Environmental Zones and Ecosystems. Along with it, WaterCapacityToken is issued and transferred, in a 1-to-1 ratio, that represents the maximum amount of usable water in an environmental zone, as measured by the scientific teams.
Environmental Zone handlers (smaller scientific crewss) open-up offers of their WaterToken assets towards recipient Industries through a Smart Contract, after communication with them and other scientific teams. With the approval of at least one other scientific team, Industries can choose the best offer of WaterToken and approve its transfer. This is the second type of digitized resource transfer performed through our system.

```
Testnet AssetID:
0bab6ae0c7da87b14334ca36557b09abe91123c929aa56ea0bbce6a582a2cdef
```

3. WasteCapacityToken
4. WaterCapacityToken

WasteCapacityTokens and WaterCapacityTokens are both utillity tokens in *Bluechain*. They initially represent the maximum amounts of allowance of Industries to dispose waste, and amount of safely usable water resources (without compromising the ecosystem) in environmental zones. As they’re transferred back and forth during WasteToken and WaterToken requests and transfers, they can be used to calculate an accurate digital representation of how damaging a specific disposal operation of waste is (different types of waste affect ecosystems differently –

for example, heavy inert metals versus cadmium or mercury) and how much water resources an industry has requested and claimed. During these calculations, the ratio of WasteToken to WasteCapacityToken might be different – for example, a scientific team can choose to approve a 20 WasteTokens to 40 WasteCapacityTokens exchange between an Industry and Environment (not 20 to 20), meaning the type of waste was twice as damaging as the usual, inert waste.

```
Testnet AssetIDs:
WasteCapacityToken:
5729393773913b62930ee8703ef095b2c7283df71b421897138ba0f82616194b
WaterCapacityToken:
91f4923d55f3133c9647f40c222edc87416dac4431a30380ba41707cba1ed3df
```

4. BlueCoin

BlueCoin represents a reward asset. It is exchanged between the Government and Industries requesting it, after the Industry sends back leftover WasteTokens, WaterCapacityTokens and WasteCapacityTokens.
The reward calculation also obeys a coefficient (*t_coefficient* in our code), a real value in (0, +inf) space. The *t_coefficient* is set at the start of each economic term, and can be dynamic towards each individual Industry (to represent individual rewards for specific good, environmentally-aware practives), or be statically applied to all Smart Contract reward transactions.
For an expanded functionality report on BlueCoin, refer to Section *3.2 – BlueCoin*.

```
Testnet AssetID:
75ea5fdb2b2dd7c93ad7d010ae36bdbb98da8714b6b212c67c1c4b6868de6ca8
```

2.4.3. Smart Contracts

Bluechain has 4 individual Smart Contracts, written on the Equity language, encompassing individual behavior for each element in our system:

a) GovernmentContract
b) IndustryContract
c) ScientificTeamContract
d) EnvironmentalZoneContract

We will continue with flowcharts of all the Smart Contracts' operations and descriptions of their individual clause methods.

2.4.3a. Government Contract operation:

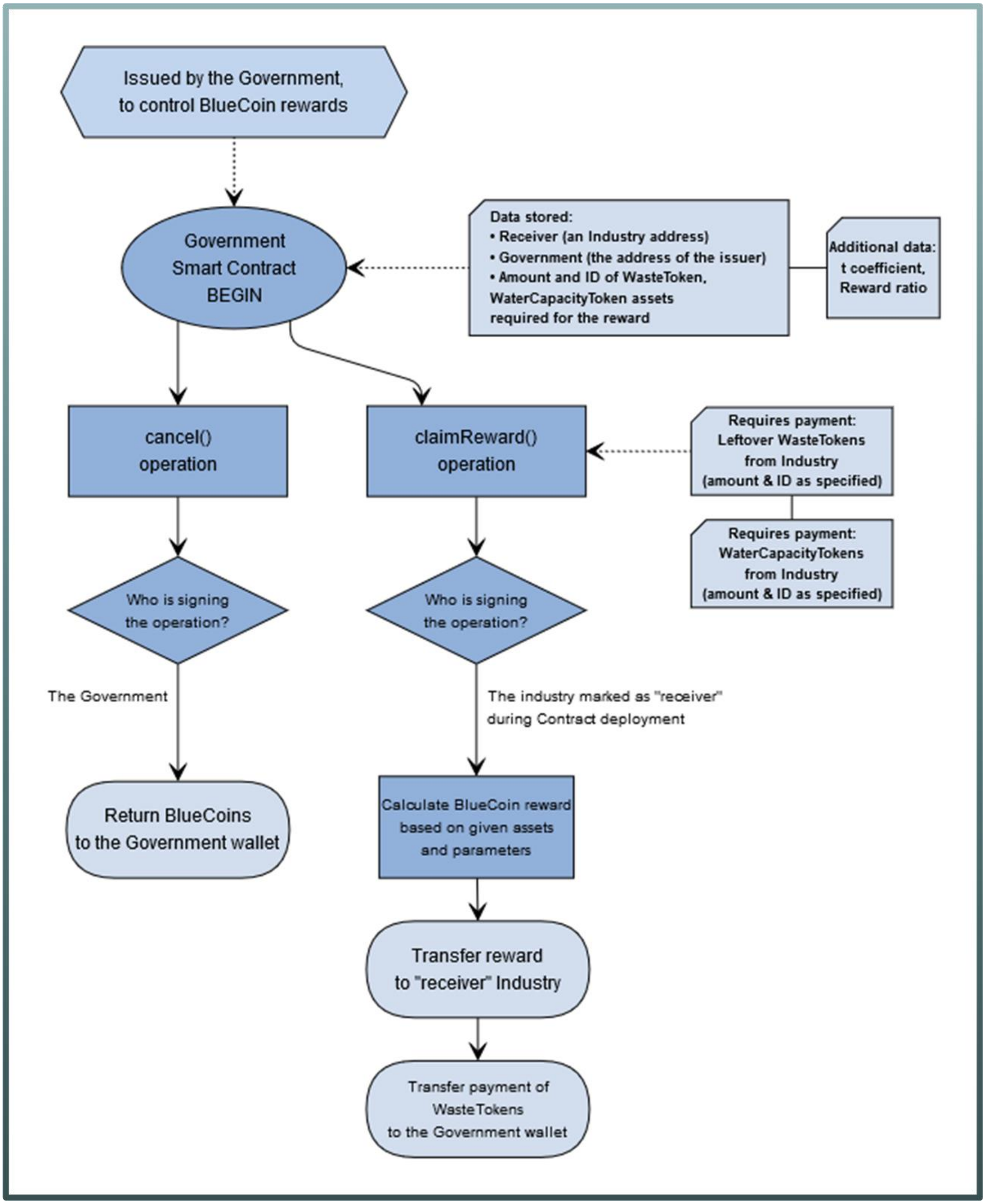


Figure 2.4.3a: *Government Contract operation flow*

Description:

The Government Smart Contract is used to calculate and control the transfer of BlueCoin rewards, back towards Industries. The calculation is initially proposed as simply the following:

$$BlueCoinReward = \left(\frac{WasteTokensReturned}{t\_coefficient}\right) * rewardRatio$$

Where:

$$rewardRatio \in \mathbb{N}(0, +\infty),$$
$$t\_coefficient \in \mathbb{R}(0, +\infty)$$

To describe each individual variable,

- $WasteTokensReturned$: The amount of WasteToken assets leftover in an Industry's wallet, at the end of an economic term, returned to the Government. The more the better.
- t_coefficient : An identifier of type of waste. The more damaging the type of waste, the higher the coefficient, and the less the reward.
- $rewardRatio$: An integer multiplier (1x, 2x…) that changes according to the needs of the Government, and can be either the same across all industry reward processes or individualized to reward specific industries better than others, for their good practices.

Clause specification:

- ```
  clause claimReward(this_sig: Signature)
  requires payment0: WasteTokenAmountRequested of WasteTokenAssetID,
  payment1: WaterCapacityTokenAmountRequested of WaterCapacityTokenAssetID
  ```

The main number-crunching method of the Government Smart Contract. It requires two payments of two amounts of Assets, WasteTokens and WaterCapacityTokens.
It calculates a reward amount based on these two amounts, and if the signatures are correct, releases the reward towards the recipient Industry.

- ```
  clause cancelReward(this_sig: Signature)
  ```

This cancel clause returns the BlueCoins locked back to the Government wallet, and dismisses the Smart Contract.

2.4.3b. Industry Contract operation:

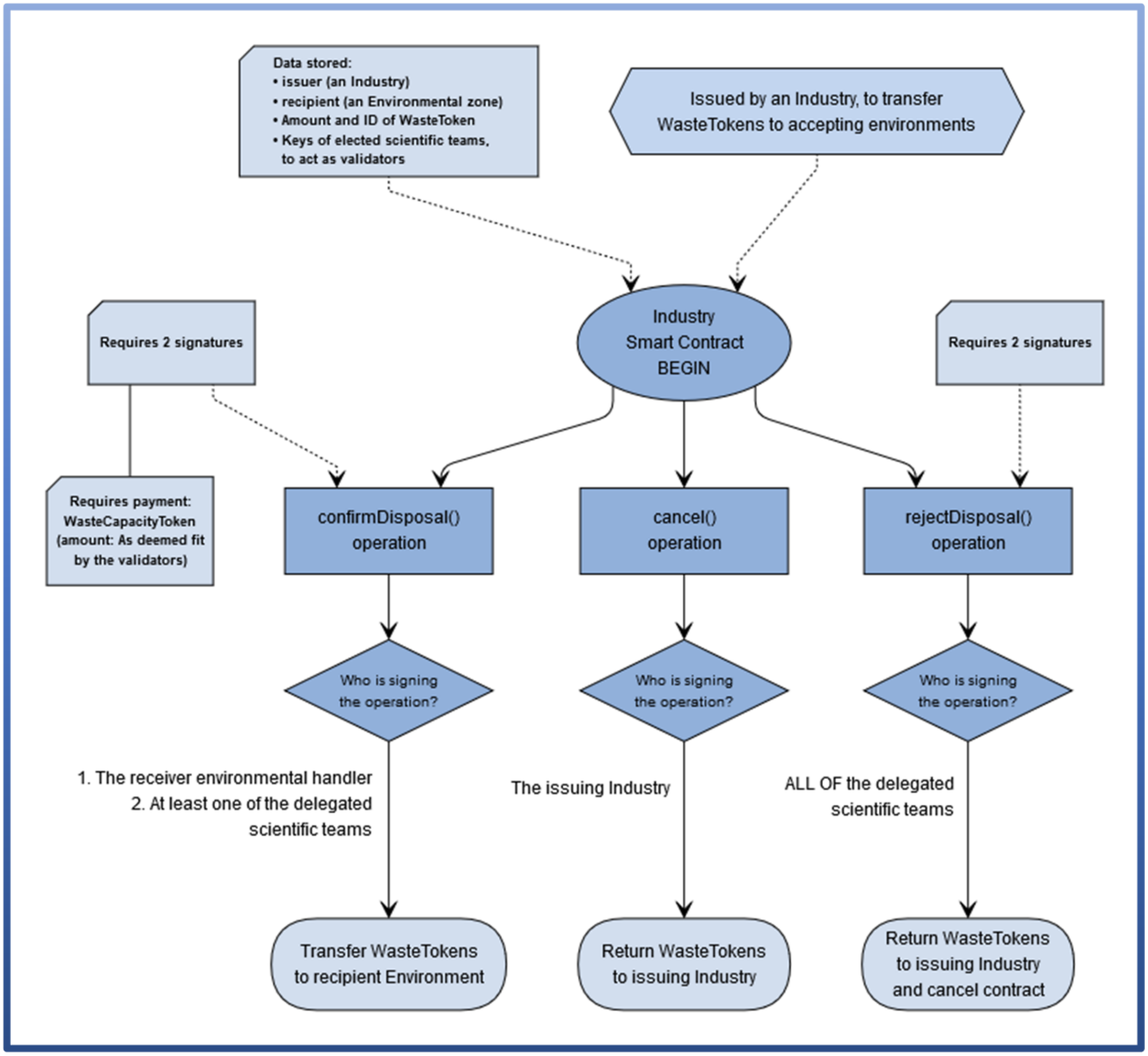


Figure 2.4.3b: *Industry Contract operation flow*

<u>Description:</u>

The Industry Smart Contract handles the transfer of WasteTokens between Industries and Environmental Zones.
Disposal operations are approved or rejected by the Environmental Zone handler and *at least one* of multiple elected Scientific Teams.
Additionally, to the approval of a scientific team, a payment of WasteCapacityTokens is also required for approval, to keep track of the ecosystem's total waste and its capacity to further waste.

Clause specification:

- `clause confirmDisposal(this_env_handler_sig, this_sci_team_sig: Signature)`
  `requires payment: WasteCapacityTokenAmountRequested of WasteCapacityTokenAssetID`

If both the Environmental Zone handler and one of the delegated Scientific Teams sign the transaction, the disposal operation goes through.

- `clause rejectDisposal(this_sci_team_sig0, this_sci_team_sig1: Signature)`

A transfer of WasteTokens can be “vetoed” and cancelled if two outside and separate Scientific Teams both agree to dismiss it. This acts as a fail-safe measure against dishonest Industries choosing to work with specific or corrupt Environmental Handler teams in specific.

- `clause cancelReward(cancelling_sig: Signature)`

If the cancelling signature matches the issuing Industry, an Industry can return the WasteToken to its wallet, and dismiss the Smart Contract

2.4.3c. Scientific Team Contract operation:

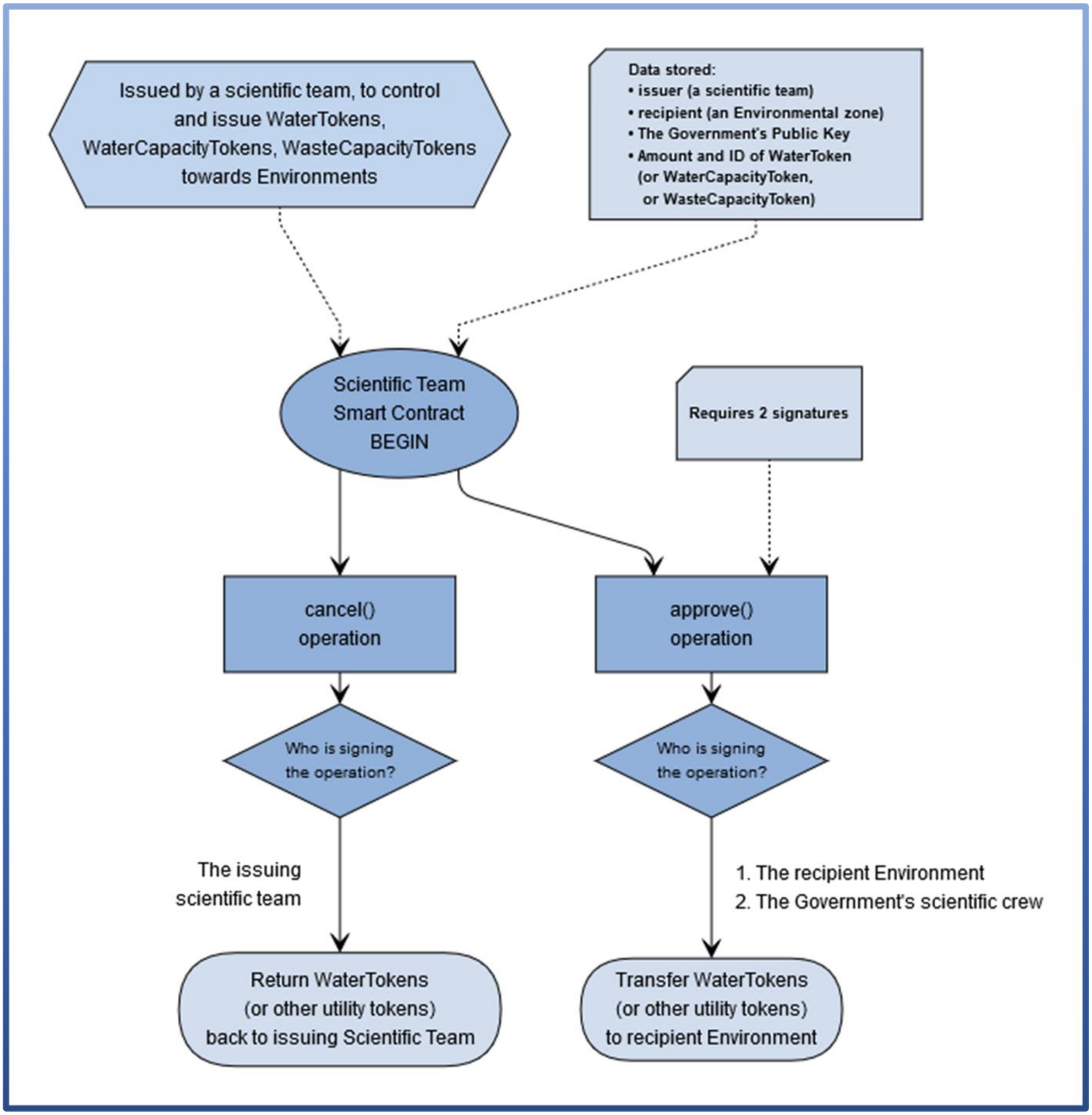


Figure 2.4.3c: *Scientific Contract operation flow*

Description:

The Scientific Smart Contract handles and controls the issuing of WaterTokens, WaterCapacityTokens and WasteCapacityTokens towards Environmental Zones.
Amounts to be transferred are calculated based on evaluation data, and for the transfer to actually go through, approval from the Government's own scientific crew is needed.

Clause specification:

- `clause approve(recipient_env_sig, government_sig: Signature)`

After the signature of the recipient Environmental Zone and the Governmment's, the transfer of Assets is approved.

- `clause cancel(cancelling_sig: Signature)`

The transfer can be cancelled by the issuing scientific team, before it goes through, and the Smart Contract gets dismissed.

2.4.3d. Environmental Zone Contract operation:

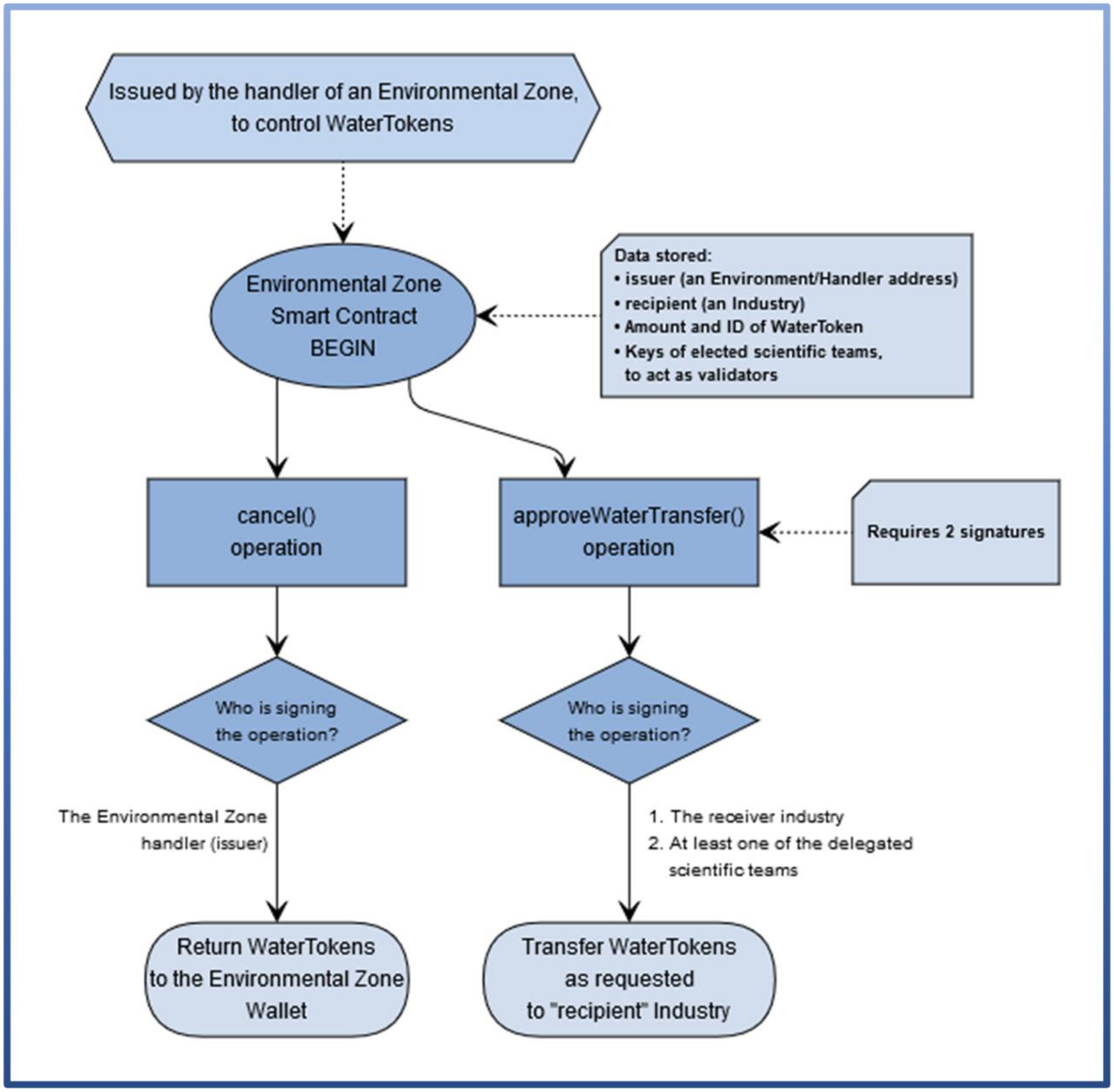


Figure 2.4.3d: *Environmental Contract operation flow*

Description:

The Environmental Zone is controlled by a Handler scientific crew of each Zone, and controls the transfers of WaterTokens from Environments towards Industries.
Approval of *at least one* of the elected Scientific Teams is required for a transfer to go through.

Clause specification:

- `clause approveWaterTransfer(this_industry_sig, this_sci_team_sig0: Signature)`

For the approval of WaterToken transfers out of an Environmental Zone, we need the signature of the recipient Industry to confirm the request, plus the signature of at least one of the Scientific Teams specified from a list in the Smart Contract’s parameters during deployment.

- `clause cancel(cancelling_sig: Signature)`

The transfer can be cancelled by the signature of the issuing Environmental Zone Handler team, before it goes through, and the Smart Contract gets dismissed.

CHAPTER 3.

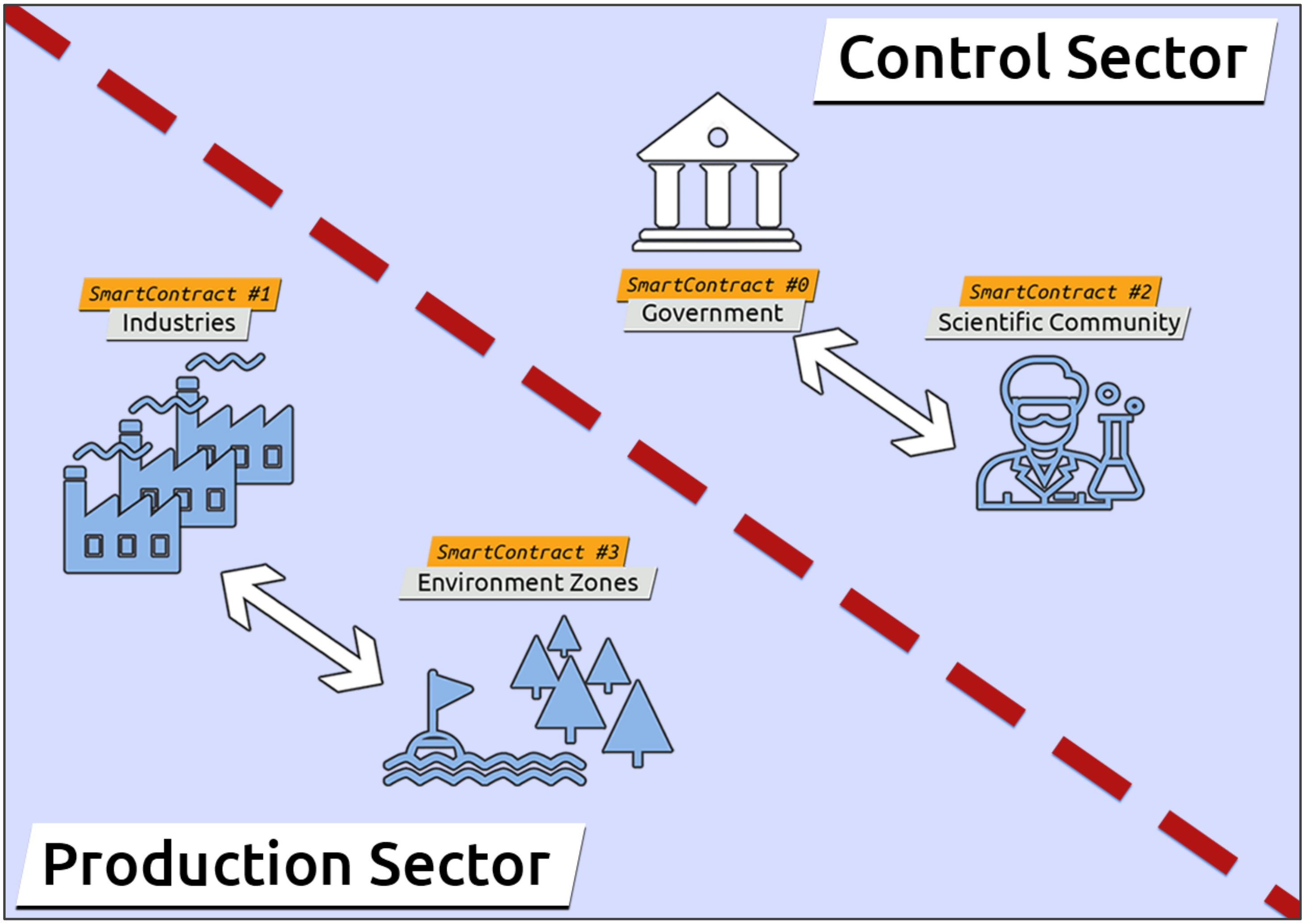
FUTURE WORK AND PROPOSALS FOR IMPROVEMENT

3.1. Generalizing Bluechain into a Business Process & Control System

Bluechain, in its current implementation, primarily organizes workflow hierarchically, with all aspects of its design fundamentally remaining transparent to all other elements in the system.

Although China's wastewater treatment processing is one of the world's most attention-worthy management arenas, *Bluechain* can be abstracted and generalized to a management system that handles much more than environmental resources, and begins treading the grounds of internal Business Process & Control systems.

The generalization we will be proposing stems from the functional division *Bluechain* performs on its managed ecosystem, a split between '**Control**' and '**Production**' sub-sectors (*Graph 11*).



Graph 11: *The main abstraction-level division performed in Bluechain*

Bluechain initially proposes a *"kinged"* **administrative** element/Smart Contract (the Government, in this Whitepaper) from which all control stems, and which directly affects the flow of transactions between other elements. However, there are other concurrent "power players" acting as **observers and validators** (the Scientific Communities) that can also influence and lock/unlock interaction streams.

All this affects the operational production activities of a **producing** element (the Industries, in our proposed system), that takes input from and creates output towards its environment.

A question arises at this point, *'how can we be sure that transactions within Bluechain or a generalized Bluechain system, correspond to reality?'*

This can be answered in two parts:
Firstly, constant monitoring by the *observation* elements on real-world activities and resource movements generates data models to explain and predict market/environmental events.
Secondly, the platform itself keeps historical data on the Blockchain (blocks before *head*), and therefore real data can always be compared to past data, to detect extremums.

This is how a **Control** sector arises in the system, a sector responsible for the healthy, proper functioning of the ecosystem, and tasked with discovering patterns and exploiting trends, for more efficient network performance.

Additionally, apart from the above, there exists a sector that acts as the operational core of the system, the **Production** sector. This is where the system's transfer activity is coalesced.

As per our design, **optimal productivity is achieved when all different parameters of production are under total investigation and completely transparent for internal review**.

In summary, *Bluechain* represents a Process & Control structure that already exists in the market, but is inefficiently implemented. Different elements in a Company need not be separated from each other, totally sealed-off in their internal processes with one-another.
A circularly organized ecosystem in that regard can organically achieve optimizations through control and communication.

In specific, by categorizing a Company's faculties into four distinct elements:

- Administration/CEO elements as Governance,
- Main & Affiliated production sites as Industries,
- Consultancy & Analysis teams as Scientific Communities,
- the Markets as Environmental zones

Bluechain can as such be generalized to a system of internal Business Process & Control that can help optimize a company's internal operation.

3.2. BlueCoin

As a major component in our project, BlueCoin represents the materialization of blue-growth-oriented economy and competition between the system's industrial resource management sector.

Every user that operationally handles & exploits resources using our project's Smart Contracts, receives rewards for being efficient & loyal to this reciprocate network. As the Control sector (*Chapter 3.1*) operates and accurately evaluates data transparency and proper sequence, it hands out rewards to good users via the BlueCoin asset.

In our case study, we use BlueCoin to recompense industries for efficiency in their wastewater treatment process, working towards minimizing their ecological impact and promoting the innovation and new technologies with higher efficacy and less energy costs. The real-world implementation of BlueCoin depends on the administrative sector.

We initially propose that BlueCoin tokens correspond to BYTOM (BTM) tokens, so that they have real market value. By generalizing and expanding *Bluechain*'s platform into several other sectors of primary and secondary Production, BlueCoin could operate as a standalone BYTOM asset that, by itself encapsulates blue growth. The initial funding can be sourced by national funds for Financial Development (*Chapter 2.2*) or by collateral profits resulting from other activities.

Moreover, in addition to BlueCoin's monetary value, it could also represent proportional **tax reductions** or **energy cost reductions** (electricity, natural gas etc.). This way, different industries can exchange blue tokens through their BYTOM Smart Contracts in a framework of a "stock market".

Finishing up, it is already established that *Bluechain*'s Assets in general, are originally issued once by the Administrator (Control sector, the Government). This is strictly essential if those assets are equal to natural resources, like water or waste. In BlueCoin's case however, the reward is dynamically and constantly changing according to environmental variables and market status. As a result, BlueCoin is exchanged with WasteTokens (or WaterTokens, or WasteCapacityTokens) not at a 1-to-1 ratio, but at a ratio that represents the environmental impact of disposal operations, and the status of the ecosystem at the current time, according to the data. The general formula for calculating the reward as per our design has been described in *Chapter 2.4.3a*.

3.3 Proposals for code expansion

We wrote and maintain proposals for expanded behaviours in the BYTOM Equity language, and our Smart Contracts use these expanded functionalities.

3.3.1. Proposal for partial unlocking of Assets through BYTOM Smart Contracts

https://github.com/Bytom/bytom/issues/1367

Our Contracts (especially the Government Smart Contract) uses partial unlocking. An approved user of a clause() does not need to send the full amount of payment required to unlock the full amount of locked assets (In the government smart contract's case, *BlueCoin*). Instead, partial unlocking is supported and the remaining percentage of leftover assets gets re-locked in a contract-within-contract invocation.

This saves on deploying multiple smart contracts for partial amounts, and avoids needing to know the amount each user is able to afford in advance.

1-to-1 payments and asset unlocking rings closer to real-world situations.

3.3.2. Proposal for the locking of multiple assets through a single BYTOM Smart Contract, either as clause payment or contract-locked asset

https://github.com/Bytom/bytom/issues/1417

Our Smart Contracts (especially the Government Contract and Industrial Contract) also use multiple assets expected as payment, so they can calculate the give-back amount of another asset.

This functionality also reflects real-world situations much better, and is a step away from traditional “apples for oranges and nothing else” transaction systems.

3.4 An AI Expert System example, proposed for the automation of Bluechain as its implementation reaches Big Data proportions.

In an earlier chapter, we talked about the possibility of Bluechain beginning to tread Big Data territory if it starts encompassing many Elements (many Scientific Teams, many Industries) in its internal ecosystems.

Data produced by a large amount of internal Elements becomes harder to analyze by conventional means and algorithms. This is where AI can begin getting introduced, to solve scaling problems.

Below is an example Expert System written in CLIPS Object Oriented Language (COOL), **designed to run autonomously and detect suspect Industries if they are connected to a damaged/overstressed Environment**. It is an expansion of the *Sensor Exoneration* problem.

CLIPS (C Language Integrated Production System) Object Oriented Language homepage and maintained repo:
https://www.csie.ntu.edu.tw/~sylee/courses/clips/bpg/node9.html

```
;;; An expert-system algorithm to detect and identify discrepancies
;;; within Industries & Environmental Zones of a Bluechain implementation.
;;; The proposed algorith runs in Rounds, and is based on the Component Exoneration
problem.
;;; ### Input: A list of overtaxed Environmental Zones, with too much measured waste
(referred to as discrepancies)
;;; ### Output: A list of all Industries connected to the discrepancy-showing
Environmental Zones,
;;;                 and are therefore suspects of bad disposal practices and require
further reviewing.
                          If non-suspect environments are overwhelmingly connected to
a suspect Industry, that Industry is exonerated.

;;; Base abstract class for this proposal, has a suspect: {true, false} field.
(defclass BluechainElement
      (is-a USER)
      (role abstract)
      (slot suspect (type SYMBOL) (allowed-symbols yes no) (default no)
)

;;; Environmental Zones are a pure child of the Bluechain element, without further
method implementations.
(defclass EnvironmentalZone
      (is-a BluechainElement)
      (role concrete)
      (patteren-match reactive)
)

;;; An Industry is connected with Environmental Zone instances, if it has performed
waste disposal operations on it.
(defclss Industry
      (is-a BluechainElement)
      (role concrete)
      (pattern-match reactive)
      (multislot connects_with (type INSTANCE-NAME))
)

;;; Object definition. They represent a micro-model of a Bluechain implementation.
(definstances industries-and-environmental-zones
      (industry0 of Industry)
      (industry1 of Industry)
      (industry2 of Industry)
      (environment0 of EnvironmentalZone)
      (environment1 of EnvironmentalZone)
      (environment2 of EnvironmentalZone)
)
```

```
;;; Initial data input Rule.
(defrule initial-question
	?x <- (initial-fact)
	=>
	(retract ?x)
	(bind $?environments (find-all-instances ((?e EnvironmentalZone)) TRUE))
	(set-strategy mea) ;;; Strategy 'lex' also works in this example
	(printout t "Which environments show up overtaxed in the data?" " $?environments
" ")
	(bind $?answer (explode$ (readline)))
	(assert (discrepancy $?answer))
	(assert (goal build-suspects))
)

;;; Initial identification of problematic environmental zones.
(defrule init-suspects
	(goal build-suspects)
	(discrepancy $? ?e $?)
	(object (is-a EnvironmentalZone)
			(name =(symbol-to-instance-name ?e))
			(suspect no)
	)
	=>
	(modify-instance (symbol-to-instance-name ?e) (suspect yes))
)

;;; Initial incrimination of Industries connected to problematic environmental zones.
(defrule propagate-suspect
	(goal build-suspects)
	(object (is-a BluechainElement)
			(name ?be)
			(suspect yes)
	)
	(object (is-a Industry)
			(name ?i)
			(connects_with $? ?be $?)
			(suspect no)
	)
	=>
	(modify instance ?i (suspect yes))
)
```

```
;;; We now change goals, and try to exonerate Industries connected to non-problematic
environments.
(defrule make-suspects-continue
	?x <- (goal build-suspects)
	=>
	(retract ?x)
	(assert (goal exonerate-industries))
)

;;; Rule of Industry exoneration, if they are connected to non-problematic
environments or industries.
(defrule exonerate-industries
	(goal exonerate-industries)
	(object (is-a Industry)
			(name ?i)
			(suspect yes)
			(connects_with $? ?e $?)
	)
	(object (is-a EnvironmentalZone)
			(name ?e)
			(suspect no)
	)
	=>
	(modify-instance ?i (suspect-no))
)

;;; Another Industry exoneration rule, due to unexplained disagreement of suspects
(defrule exonerate-industries-special
	(goal exonerate-industries)
	(object (is-a Industry)
			(name ?i)
			(suspect yes)
			(connects_with $?environments)
	)
	(not (object (is-a Environment)
				(name ?e0 &: (member $? ?e0 $?environments))
				(suspect no)
		)
	)
	(object (is-a Environment)
			(name ?e1 &: (not (member $? ?e1 $?environments)))
			(suspect yes)
	)
	=>
	(modify-instance ?i (suspect no))
)
```

```
;; Change goals from (now finished) Industry Exoneration to Announce Results
(defrule exonerate-industries-finished
	?x <- (goal exonerate-industries)
	=>
	(retract ?x)
	(assert (goal announce-results))
)

;;; Anounce final results rule
(defrule announce-results
	(goal announce-results)
	(object (is-a BluechainElement)
			(name ?be)
			(suspect yes)
	)
	(not (object (is-a Environment)
				(name ~?be)
				(suspect yes)
				(connects_with $? ?be $?)
		)
	)
	=>
	(printout t (class ?be) " " (instance-name-to-symbol ?be) " is a suspect." crlf)
)
```

CHAPTER 4.

BIBLIOGRAPHY & REFERENCES

1) OECD (2007), “Environmental Performance Review of China”, Chapter: Water

2) Zhuomin Wang & Dongguo Shao & Westerhoff Paul (2007), “Wastewater discharge impact on drinking water sources along the Yangtze River (China)”, Science of the Total Environment 599–600 (2017) 1399–1407

3) FECO/MEP-PRC & China-Water-Risk (2016), “Water-nomics of the Yangtze River Economic Belt”

4) GCiS China’s Strategic Research, “China’s 13th Five Year Plan & the Wastewater Treatment Industry”, China Insights-Industrial Article, GCiS Official Platform

5) Yuhua Zhu & Ning Duan & Xuefang Wu & Hao Fang (2018), “COD Discharge Limits for Urban Wastewater Treatment Plants in China Based on Statistical Methods”, Water 2018, 10:777

6) Probe International (2013), “An Investigation into Wastewater Treatment in the Three Gorges Reservoir Basin”

7) Debra Tan (CWR-2016), “Beautiful China 2020: Water & The 13th FYP”, Official CWR Platform China Water Risk

8) Ministry of Ecology & Environment The People's Rebuplic of China (22/10/2018), "China vows to further protect environment while fighting poverty", *Ministry of Ecology & Environment announcement*

9) Marglin, Stephen A.; Schor, Juliet B. *The Golden Age of Capitalism*. Clarendon Press. p. 1. *Retrieved 2015-12-20*.

10) “Artificial Intelligence”, 3rd edition, G. Vlahavas, P. Kefalas, N. Vassileiades, F. Kokkoras, E. Sakellariou, ISBN: 978-960-8396-64-7

11) Z. Yang & H. Wang & Y. Saito & J. D. Milliman & K. Xu & S. Qiao & G. Shi (2006), Dam impacts on the Changjiang (Yangtze) River sediment discharge to the sea: The past 55 years and after the Three Gorges Dam, WATER RESOURCES RESEARCH, VOL. 42, W04407, doi:10.1029/2005WR003970

12) Chuan Fu & Jinsong Guo & Jie Pan & Junsheng Qi & Weisheng Zhou (2009), "Potential Ecological Risk Assessment of Heavy Metal Pollution in Sediments of the Yangtze River Within the Wanzhou Section, China", Biol Trace Elem Res (2009) 129:270–277, DOI 10.1007/s12011-008-8300-y

13) “GitHub repo of the Bluechain project”, https://github.com/Agouri/Bluechain

14) “GitHub wiki of the Bluechain project, and Starting Developer’s Guide, by the Bluechain team”, https://github.com/Agouri/Buechain/wiki

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