Study on the horizontal ecological compensation scheme between southern Zhejiang counties --- Take Aojiang river basin as an example

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Abstract. The valley ecological protection compensation has been widely proposed in recent years as a policy to adjust the environmental and economic benefits of valley ecological protection. Horizontal ecological protection compensation embodies the basic concept of equal rights and responsibilities and encourages the upstream region to provide better ecological products and realize value compensation, so as to truly motivate the green development in the upstream region. Taking the Aojiang river basin in southern Zhejiang as the research object, this paper analyzes the framework system, compensation scope, subject and object, compensation basis, assessment method and accounting method of horizontal ecological compensation between counties. Two horizontal ecological compensation plans between southern Zhejiang counties are obtained. Plan A: The assessment sections are set up in Aojiang river Xilu village (A-1 #), Cangnan boundary section of Hushan inland river (A-2 #), Cangnan boundary section of Xiaojiangtang river (A-3 #), Cangnan boundary section of Hengyang branch river (C#) and Meixi Pingyang boundary section (D#). The fund allocation ratio is 59%, 6%, 6%, 18% and 11% respectively. Plan B: The assessment sections are set up in Aojiang river Liming village (B#), Cangnan boundary section of Hengyang branch river (C#) and Meixi Pingyang boundary section (D#). The fund allocation ratio is 67%, 21%, 12% respectively. It will provide reference and technical support for Wenzhou to establish a scientific and feasible horizontal ecological compensation mechanism in the upper and lower reaches of the city basin and the left and right banks by 2020.

1. Introduction

The various waters, upstream and downstream of the river is an inalienable organic whole. Currently the water environment protection problem is serious and the upstream and downstream linkage is urgently needed to improve the work efficiency and capital performance in the basin ecological environment protection and governance[1, 2]. However, the watershed is often divided that to different administrative units, which have complex interests in the water resources and environment, resulting in unclear responsibilities of each administrative unit for the protection and utilization of the watershed and more water disputes across the watershed[3]. The valley ecological protection compensation and pollution compensation has been widely proposed in recent years as a policy to adjust the environmental and economic benefits of valley ecological protection. It means to implement the internalization of the externality of watershed ecological protection and the "beneficiaries" of the achievements of watershed
ecological protection should pay the corresponding costs to realize the reasonable return to the investors of watershed ecological protection. Horizontal ecological protection compensation embodies the basic concept of equal rights and responsibilities and encourages the upstream region to provide better ecological products and realize value compensation, so as to truly motivate the green development in the upstream region. In order to clarify the relationship of rights and responsibilities, alleviate the contradiction between water resources and water environment, and promote the coordinated development of upstream and downstream regions, horizontal ecological compensation is imperative. China is vigorously promoting ecological compensation for watershed protection[4, 5].

At present, many practices have been made in horizontal ecological compensation of river basin at home and abroad[6]. In order to improve the quality of drinking water in New York City, the relevant departments including New York City and New York state invested 500 million dollars in Catskill and Delaware water conservation projects through independent negotiation[7]. Watershed ecological compensation in Costa Rica is mainly government-led marketing compensation, which regulates river runoff through afforestation and protection of watershed vegetation. The ecological compensation of the Elbe river basin in Germany is mainly based on horizontal compensation, and the transfer payment from the rich areas to the poor areas makes the water quality of the upper reaches of the Elbe river basically meet the drinking water standard and obtain obvious economic and social benefits[8]. Domestically, in 2015, the Luanhe basin carried out horizontal ecological compensation in the basin with the financial support of the comprehensive improvement of land and rivers, funded by Tianjin and Hebei province in the upstream and carried out project financial compensation for Liaoning and Inner Mongolia in the downstream[9]. In 2016, Jiangxi and Guangdong province signed the "Horizontal Ecological Compensation agreement for the Upper and Lower reaches of the Dongjiang river basin". The fund compensation was linked to the result of water quality assessment. Each province contributed 100 million yuan each year to set up a compensation fund. The specific compensation is allocated according to the completion of assessment objectives. In 2016, the ministry of finance and the ministry of environmental protection jointly held a meeting in Longyan city of Fujian to promote the construction of horizontal ecological compensation mechanism in the upper and lower reaches of some provinces. Guangdong signed water environment compensation agreements for the Ting river and Han river basin and the Jiuzhou river basin with Fujian and Guangxi Zhuang autonomous region respectively, which has become an important progress in promoting horizontal ecological compensation for river basins in China[10]. It also provides a good example for the Pan-Pearl River Delta, Guangdong and Hong Kong to realize cross-regional ecological cooperation and joint prevention of pollution.

Focusing on the water ecological civilization construction of Wenzhou river basin and starting from the holistic management of watershed ecosystem, the goal is to promote the improvement of water environment quality, the health and safety of water ecology, and the appreciation of water ecological environment assets. Based on the analysis of the current situation and problems of water environment, water resources development and utilization, and ecological protection compensation in cross-administrative region watershed of our city, taking into comprehensive consideration of the differences in economic development stages of the upper and lower reaches of the river basin and the left and right banks as well as the imbalance in the supply of public services for the ecological environment. To explore the horizontal ecological compensation benchmark of river basin, determine the compensation standard reasonably, innovate and establish multiple compensation methods and put forward suggestions on strengthening the organization implementation, performance assessment, joint prevention and control and other related safeguard measures. So as to provide reference and technical support for Wenzhou to establish a scientific and feasible compensation mechanism for ecological protection in the upper and lower reaches of the city basin and the left and right banks by 2020.

2. General situations of research region
The Aojiang main stream has a total length of 82.47 km and a total basin area of 1521.49 km². As shown in figure 1, the water system is divided into two branches: the north branch is the main stream, which flows through Shunxi, Nanyan, Shanmen and Shuitou tidal area of Pingyang county, and then flows into the East China Sea through Mabu and Aojiang town. The catchment area of Beigang basin is 826.8 km², the main tributaries are Shunxi, Yuexi, Huaxi, Qingjiexi and Nanyanxi, etc. The south branch is called Hengyang branch river with a total length of 27.3 km. It crosses the whole Cangnan county, passes Junxi, Qiaodun and Lingxi, and then flows into Aojiang river from Hushan inland river to Xiaqiao sluice, Xiaojiangtang river to Xiaojingang sluice, and Hengyang Zhijiang river to Zhujiazhan sluice. The catchment area of Nangang basin is 753.6 km². The north and south ports converge in the Fengjiang river and flow into the East China Sea. According to the statistics of Daitou hydrological station, the annual average flow rate of Aojiang river is 16.2 m³/s, coefficient of variation (CV) is 0.35, runoff is $5.13 \times 10^8$ m³, runoff depth is 1490 mm, runoff modulus is 47.1 L/s•km², and runoff coefficient is 0.72. Based on the statistics of Yuao station of Hengyang tributary, the average annual discharge of the Nangang river is 5m³/s, accounting for about 30% of the mainstream runoff. The average annual flow of Meixi, a tributary below Mabu, is 2.95 m³/s. The Xiaojiangtang river and Hushan inland river are mainly controlled by sluice. According to the estimation of Water Department, the 1h water discharge per hole is $2.16 \times 10^5$ m³, and the discharge is 10 h each time with 25 times a year. The annual average flow is 1.71 m³/s.

3. Methodology

3.1. Frame system

The aim of ecological compensation mechanism in each basin is to promote rational development and utilization of water resources, improvement of water environment quality, and ecological protection and restoration in upstream water conservation areas, combining with the water ecological function zoning to control unit water quality management. Mainly focus on the establishment of the ecological compensation mechanism of the upper and lower reaches and the left and right banks of the basin based on the water quality and quantity targets. The key points of the compensation mechanism include the compensation object, compensation basis, method, fund, management and distribution, guarantee measures for mechanism implementation, etc. The frame system is shown in Figure 1.

3.2. Compensation scope, subject and object

In accordance with the principle of "unified rights and responsibilities, reasonable compensation" and "who benefits, who compensates" for ecological compensation, it is required to scientifically define the rights and obligations of the protector and the beneficiary, so as to form the operating mechanism of the beneficiary paying and the protector receiving reasonable compensation. The improvement of watershed ecological service function and environmental quality has significant public benefits, and the government in the upper and lower reaches of the basin and the left and right bank are often the main compensation subject. The compensation object is the ecological function supply area, which is also mainly the relevant government departments. For the horizontal ecological compensation of the upper and lower reaches of the river basin and the left and right banks, the upstream area or the downstream area may be both the compensation subject and the compensation object. The final confirmation depends on the specific assessment results. According to the agreement of both parties, it is assumed that when the upstream water quality reaches the standard, the upstream shall be compensated by the downstream, and the downstream shall be the compensation subject and the upstream shall be the compensation object; when the upstream water quality is substandard, the upstream needs to compensate the downstream, then the upstream is the compensation subject, and the downstream is the compensation object.

For the complex water systems, where there are many compensations and objects to be compensated, the organization and transaction costs in the negotiation process of ecological compensation are high and it is not easy to reach an agreement. At the same time, once multiple subjects are involved in the
scope of ecological compensation, the interest relationship will be more complicated, and the definition
of the beneficiary and the compensator will be difficult. Therefore, when establishing the cross-basin
upstream and downstream horizontal ecological compensation mechanism, it is suggested to establish
between regions where the upstream and downstream relationship is relatively clear.

3.3. Compensation basis and assessment method
According to “The opinions of the general office of Zhejiang provincial people's government on the
establishment and improvement of the financial incentive mechanism for green development” (Zhejiang
administration office [2017] No. 102), “Suggestions on the implementation of establishing a horizontal
ecological protection compensation mechanism for upstream and downstream rivers in Zhejiang
province by Zhejiang finance and other four departments” (Zhejiang finance establishment [2017] No.
184), etc. The horizontal ecological compensation of the basin mainly takes the water quality and
quantity of the junction section of the basin and the total water consumption and water use efficiency of
the upstream counties (cities and districts) as the compensation benchmark and takes the data of the
automatic water quality monitoring system of the junction section as the assessment basis.

3.3.1. Setting of assessment section
In principle, the assessment section should be the junction section of the upper and lower reaches, that
is the upstream exit section. However, when the situation is complex, the upstream and downstream
regions may involve multiple administrative regions, then the selection of the section should consider
the actual situation of the basin and choose the river and area with relatively clear upstream and
downstream relationship as the compensation scope. In addition, the section position should be adjusted
reasonably according to the interest of both parties and the river section affected by a single
administrative area is preferred.

3.3.2. Setting of assessment indicators
The water quality of the transboundary section of the basin can only be better and cannot be worse.
Therefore, the average concentration value of each indicator in the first three years of monitoring section
is taken as the basic limit value. The water quality indicators select main pollution factors, such as
permanganate index, ammonia nitrogen and total phosphorus, etc. If there are other pollution factors
that are substandard, the factors can be adjusted.

If the assessment section is the existing automatic monitoring station, the water quality data shall be
the annual mean value of each index of the automatic station. The upstream and downstream areas shall
conduct joint review of the data of automatic monitoring stations. In case of abnormal fluctuation of
water quality caused by force majeure during the monitoring period, the upstream and downstream areas
shall discuss the details of manual water quality monitoring. When there is a dispute over the data
between the two places, the Zhejiang Environmental Monitoring Center shall organize arbitration, and
the arbitration result shall prevail.

In accordance with the total water consumption and water use efficiency in upstream areas and based
on the requirements of green development assessment and water resource consumption control, the total
water consumption, industrial and domestic water consumption, annual water consumption per ten
thousand yuan of GDP, and water consumption per ten thousand yuan of added industrial value
determined by the provinces and cities could be set as the basic limits. The water quantity and efficiency
shall be subject to the approved data in Wenzhou water resources bulletin. If there is any objection, the
provincial water resources department shall organize the consultation between the upstream and
downstream areas.

3.4. Accounting method
The compensation method carries out comprehensive evaluation on water quality, water quantity, water efficiency and other factors, and determines the compensation direction and compensation funds. The detailed measurement methods are as below:

Water quality compensation index \( P \)

According to “The surface water environmental quality standards” (GB3838-2002), the basic limit is set as the average concentration in the first three years of three assessment indicators, permanganate index, ammonia nitrogen and total phosphorus. The compensation index \( P \) is calculated and the compensation direction is determined. The detailed method is as below:

\[
P = k_0 \times \sum_{i=1}^{3} k_i \frac{C_i}{C_{io}}
\]

in the equation: \( P \) —— The compensation index of the assessment section;

\( k_0 \) —— water quality stability factor, considering the natural factors such as rainfall and runoff, \( k_0 \) is set as 0.80;

\( k_i \) —— index weight coefficient, to average the three index, \( k_i \) is set as 0.33;

\( C_i \) —— the average annual concentration of an index;

\( C_{io} \) —— the basic limit of an index.

Water quantity and efficiency compensation index \( Q \)

According to the requirements of green development assessment and water resource consumption control, as well as the basic limits which are the total water consumption, industrial and domestic water consumption, annual water consumption per ten thousand yuan of GDP and water consumption per ten thousand yuan of added industrial value determined by the province and the city, the water quantity and efficiency compensation index is comprehensively calculated as below:

\[
Q = A_0 \times \sum_{i=1}^{4} k_i \frac{W_i}{W_{io}}
\]

in the equation: \( Q \) —— water quantity and efficiency compensation index;

\( A_0 \) —— unbalance factor, \( A_0 \) is set as 0.90;

\( k_i \) —— index weight coefficient, the index weights of total water consumption, industrial and domestic water consumption are 0.2 respectively, the water consumption per ten thousand yuan of GDP and per ten thousand yuan of industrial added value are 0.3 respectively;

\( W_i \) —— the actual value of an index in the upstream region in that year;

\( W_{io} \) —— the basic limit of an index.

The water quality compensation index \( P \) and water quantity and efficiency compensation index \( Q \) are used with the weight of 7:3 to calculate the ecological compensation index. If the compensation index is less than or equal to 1, the downstream region shall compensate to the upstream region; If the compensation index is more than 1 or serious water pollution accident occurs in the upstream region, the upstream region shall compensate to the downstream region. The upstream and downstream compensation funds shall be incorporated into the overall compensation funds to be used for the ecological protection, construction and compensation of the river basins in the region.

4. Results and discussion
4.1. Compensation scope, subject and object

Table 1 shows 1958~2012 average monthly runoff in Daitou hydrological station. Based on the analysis of the relationship between the rivers and the administrative regions, the river basin from the upper reaches of Aojiang to the middle reaches in Liming village of Xiaojiang town basically located in Pingyang county, except for a small part located in Wencheng and Cangnan; The middle reaches in Liming village to Xilu village of the main stream is in Pingyang with many tributaries. The tributary Hushan inland river and the Xiaojiangtang river are mostly located in Cangnan with a small part in Pingyang. The downstream Xilu to the estuary is located at the junction of Pingyang and Cangnan. The largest tributary, Hengyang tributary, flows into it from the Zhujiazhan sluice and Meixi in Pingyang flows into it from Meipu. Most part of the Hengyang tributary basin are in Cangnan except for a small part in Taishun. On the lower left bank is the Aojiang plain, and on the right bank is the Jiangnan plain. The Aojiang river and the Jiangnan river flow into it and then to the sea. (Table 2)

Table 1 1958 ~2012 Average monthly runoff in Daitou hydrological station

(UNIT: one hundred million / m3)

| Month | Average Runoff Distribution rate | P~20 % High flow year (1969) | P~50 % Average year (1978) | P~75 % Low flow year (1957) | P~95 % Dry year (1967) |
|-------|---------------------------------|-----------------------------|---------------------------|-----------------------------|------------------------|
| 1     | 0.10                            | 2.0                         | 0.37                      | 0.13                        | 0.08                   | 0.06                   |
| 2     | 0.17                            | 3.3                         | 0.58                      | 0.17                        | 0.22                   | 0.13                   |
| 3     | 0.31                            | 6.1                         | 0.50                      | 0.45                        | 0.34                   | 0.32                   |
| 4     | 0.36                            | 7.0                         | 0.31                      | 0.63                        | 0.27                   | 0.42                   |
| 5     | 0.53                            | 10.2                        | 0.92                      | 0.70                        | 0.58                   | 0.52                   |
| 6     | 0.73                            | 14.1                        | 0.69                      | 1.11                        | 0.41                   | 0.50                   |
| 7     | 0.59                            | 11.5                        | 0.47                      | 0.07                        | 0.07                   | 0.13                   |
| 8     | 0.94                            | 18.1                        | 0.74                      | 1.40                        | 0.46                   | 0.17                   |
| 9     | 0.89                            | 17.3                        | 1.46                      | 0.13                        | 0.82                   | 0.06                   |
| 10    | 0.31                            | 6.1                         | 0.37                      | 0.06                        | 0.42                   | 0.02                   |
| 11    | 0.14                            | 2.6                         | 0.11                      | 0.14                        | 0.08                   | 0.22                   |
| 12    | 0.09                            | 1.7                         | 0.06                      | 0.04                        | 0.11                   | 0.10                   |
| Whole year | 5.16                          | 100                        | 6.58                      | 5.03                        | 3.86                   | 2.65                   |

Table 2 Major tributaries of the Aojiang river

| No. | Tributaries | Length (km) | The basin area (km²) | Average flowrate of years (m³/s) | Runoff (a hundred million m³) | Flows into |
|-----|-------------|-------------|----------------------|---------------------------------|-------------------------------|------------|
| 1   | Beigang basin | /           | 826.8                | /                               | /                             | /          |
| 1   | Shunxi      | 30          | 215                  | 9.85                            | 3.1                           | Lingjiao   |
| 2   | Yuexi       | 16.7        | 48.1                 | 2.34                            | 0.73                          | Hengxi     |
| 3   | Huaixi      | 18.89       | 95.34                | 4.15                            | 1.31                          | Fanyan     |
| 4   | Qingjixi    | 10.3        | 31.6                 | 0.54                            | 0.48                          | /          |
| 5   | Nanyanxi    | 8.7         | 17.3                 | 0.26                            | 0.82                          | /          |
| 6   | Naocunxi    | 12.6        | 38.5                 | 1.8                             | 0.57                          | Daitou     |
| 7   | Fengwoxi    | 17.14       | 52.23                | 2.18                            | 0.69                          | Jinfeng    |
| 8   | Daixi       | 23.34       | 99.8                 | 4.12                            | 1.3                           | Xianqiao   |
Based on the analysis of the distribution of the Aojiang river and the principle of clear rights and responsibilities, combining with the influence scope of the basin, it is suggested to establish horizontal ecological compensation in the Aojiang river main stream and the largest Hengyang tributary basin. At the same time, the relatively large tributaries like Meixi, Xiaojiangtang and Hushan inland river can also be included in the compensation scope. Most of the upper reaches of Aojiang main stream is in Pingyang county, the lower left bank is Pingyang county, and the right bank is Cangnan county. The upstream of Hengyang tributary is in Cangnan county and the upstream of Meixi is in Pingyang county. The downstream area is consistent with the main stream with Pingyang county on the left bank and Cangnan county on the right bank. The upper reaches of Xiaojiangtang river and Hushan inland river are in Cangnan county and the lower reaches are in Pingyang county. (see Table 3)

Table 3 The relation between upstream and downstream and left and right bank of Aojiang river basin

| River            | Upstream                                      | Downstream                                  |
|------------------|-----------------------------------------------|---------------------------------------------|
| Aojiang main stream | Pingyang county: Shunxi town, Shanmen town, Nanyan town, Naocun township, Qingjie township, Fengwo township, Tengjiao township, Shuitou township, Xiaojiang township | Left bank: Aojiang town in Pingyang county |
|                  |                                               | Right bank: Longgang town in Cangnan county |
|                  |                                               | Left bank: Aojiang town in Pingyang county |
|                  |                                               | Right bank: Longgang town in Cangnan county |
| Meixi            | Pingyang county: Aojiang town                 |                                             |
|                  |                                               | Left bank: Aojiang town in Pingyang county |
| Hengyang tributary | Cangnan county: Juxi town, Qiaodun town, Zhaoxi town, Lingxi town, Longgang town |                                             |
|                  |                                               | Left bank: Aojiang town in Pingyang county |
|                  |                                               | Right bank: Longgang town in Cangnan county |
| Xiaojiangtang river | Cangnan county: Lingxi town                  | Xiaojiang town in Pingyang county          |
| Hushan inland river     | Cangnan county: Lingxi town                  | Xiaojiang town in Pingyang county          |

According to the analysis above, the compensation scope of the upstream region basically does not include the left and right bank while the downstream region includes the left and right bank. Taking Aojiang river main stream as an example, the subject and object of upstream compensation is Pingyang and the downstream includes Pingyang county and Cangnan county. The compensation is within Pingyang county which is not belong to the horizontal compensation between counties. Therefore, this part of compensation is not included in the horizontal ecological compensation and the Cangnan county is the main compensation object in downstream. With the above method, the proposed implementation of the compensation scope, subject and object is determined as shown in the Table 4.

Table 4 Compensation scope, subject and object in Aojiang river basin
4.2. Setting of assessment section

According to the distribution of the Aojiang river (see figure 1 and Table 5), the junction section of the main stream between Pingyang county and Cangnan county is actually Xilu village. However, the two upstream tributaries of this section are in Cangnan county, the setting of the section can follow two plans below:

Plan A: The assessment section is set in Xilu village (i.e. the location of A-1# in figure 1, the junction of Xiaojiang town, Aojiang town and Longgang town). The upstream is Pingyang county, the downstream left bank is Pingyang county, and the right bank is Cangnan county. Considering the influence of the Hushan inland river and the Cangnan county section of Xiaojiangtang river on the water quality of this section, these two tributaries are also included in the compensation scope. The assessment sections were set up separately in the boundary sections of Hushan inland river and Xiaojiangtang river Cangnan section (the location of A-2 # and A-3 # in figure 1 at the junction of Lingxi town and Xiaojiang town). The upstream is in Cangnan county, and the downstream is in Pingyang county. Three sections were checked and implement horizontal ecological compensation simultaneously.

Plan B: In order to clarify the rights and responsibilities and operate easily, the assessment section of the main stream is moved up to set in Liming village in Xiaojiang town (location of B# in figure 1). The upper reaches of the compensation area are all in Pingyang county, the lower left bank is in Pingyang county and the right bank is in Cangnan county.

The junction of Cangnan and Pingyang of Hengyang tributary is located at Zhujia sluice. The upstream of compensation area is basically in Cangnan county, the left bank of downstream is in Pingyang county and the right bank is in Cangnan county. Therefore, it is suggested to set up the assessment section at the entrance to the river. According to the current setting of the assessment section, the city-controlled section (the location of C# in figure 1, the junction of Longgang town and Aojiang town) that is Zhujia sluice station can be taken as the assessment section.

The junction of Cangnan and Pingyang of Meixi river is located at Huilong village in Qiancang town. The upstream of compensation area is in Cangnan county, the left bank of downstream is in Pingyang county and the right bank is in Cangnan county. Therefore, it is suggested to set up the assessment section at the entrance to the river. According to the current setting of the assessment section, the city-controlled Dongyang station (the location of D# in figure 1) can be taken as the assessment section.

Table 5 Horizontal ecological compensation section of Aojiang river basin

| Assessment river     | Assessment section     | Position of section                                      |
|----------------------|------------------------|----------------------------------------------------------|
| Aojiang main stream  | Xilu village (A-1#)    | Junction section of Xiaojiang town in Pingyang county and Longgang town in Cangnan county |
| Hushan inland river  | Xiaqiao sluice (A-2#)  | Junction section of Lingxi town in Cangnan county and Aojiang town in Pingyang county |
| Xiaojiangtang river  | Xiaojiang sluice (A-3#) | Junction section of Lingxi town in Cangnan county and Aojiang town in Pingyang county |
4.3. Setting of Water Quality Assessment Target

According to the principle of water quality assessment target setting, the average concentration value of the monitored indexes in the assessment section of permanganate index, ammonia nitrogen and total phosphorus in the first three years is set as the basic limit value. If the national or provincial water quality targets have been determined, the compensation standard shall be higher than the national or provincial requirements. The water quality assessment targets of some sections were simulated by referring to the water quality monitoring results from 2015 to 2017 of conventional assessment sections in Aojiang river basin. See Table 6 for details. For the sections where no conventional assessment stations have been set up, the water quality should refer to the monitoring results of water or the quality of surrounding water.

Table 6 Monitoring results of section indicators in assessment river (Unit: mg/L)

| Assessment river | Assessment section | Indicators               | 2015 | 2016 | 2017 | Average in three years | Water quality standard | Suggested limit |
|------------------|--------------------|--------------------------|------|------|------|-------------------------|------------------------|-----------------|
| Aojiang main stream | Xilu village (A-1#) | Permanganate Index       | 3.042| 1.66 | 2    | 2.234                   | 6                      | 2.234          |
|                  |                    | Ammonia-nitrogen         | 2.078| 0.851| 0.99 | 1.306                   | 1                      | 1               |
|                  |                    | Total Phosphorus         | 0.188| 0.107| 0.138| 0.144                   | 0.2                    | 0.144           |
|                  |                    | Permanganate Index       | 3.83 | 2.70 | 3.10 | 3.21                    | 6                      | 3.21            |
| Hengyang tributary | Zhujia sluice (C#) | Permanganate Index       | 0.79 | 0.82 | 0.92 | 0.84                    | 1                      | 0.84            |
|                  |                    | Ammonia-nitrogen         | 0.32 | 0.27 | 0.25 | 0.28                    | 0.2                    | 0.2             |
| Hengyang tributary | Zhujia sluice (C#) | Total Phosphorus         | 0.32 | 0.27 | 0.25 | 0.28                    | 0.2                    | 0.2             |
| Meixi            | Dongyang (D#)      | Permanganate Index       | 4.23 | 2.89 | 3.40 | 3.51                    | 6                      | 3.51            |
Note: the target of water environment functional area in each section is class III.

4.4. Source, distribution and usage of compensation funds

Pingyang county and Cangnan county jointly set up the horizontal ecological compensation funds. According to the “Suggestions on the implementation of establishing a horizontal ecological protection compensation mechanism for upstream and downstream rivers in Zhejiang province by Zhejiang finance and other four departments” (Zhejiang finance establishment [2017] No. 184), each of the upper and lower reaches should contribute 5 million to 10 million yuan. The two county-level finance departments set up special funds which should belong to the annual fiscal budget. To integrate the special funds used by the state and provincial governments in agriculture, forestry, water conservancy, environmental protection, poverty alleviation, urban construction, technological transformation, and science and technology for watershed ecological protection and water environment improvement. It also will be included in the special funds for horizontal ecological compensation.

The fund distribution of each assessment section is mainly in accordance with the water flow. According to the setting scheme of the section and the fund allocation method, the fund distribution of the two schemes is calculated as below:

Plan A: The assessment sections were set up in Aojiang river Xilu village (A-1 #), Cangnan boundary section of Hushan inland river (A-2 #), Cangnan boundary section of Xioajiangtang river (A-3 #), Cangnan boundary section of Hengyang branch river (C#) and Meixi Pingyang boundary section (D#). The upstream and downstream contributes 8 million separately. The distribution result of compensation funds is shown in Table 7.

| Assessment river  | Assessment section | Average flow rate of years (m³/s) | Proportion of compensation funds | Fund amount (ten thousand yuan) | Upstream                  | Downstream                  |
|------------------|--------------------|----------------------------------|----------------------------------|---------------------------------|---------------------------|-----------------------------|
| Aojiang main stream | Xilu village (A-1#) | 16.2                             | 59%                              | 472                             | Pingyang county           | Cangnan county              |
| Hushan inland river        | (A-2#)            | 1.71                             | 6%                               | 48                              | Cangnan county             | Pingyang county             |
| Xiaojiangtang river            | (A-3#)            | 1.71                             | 6%                               | 48                              | Cangnan county             | Pingyang county             |
| Hengyang tributary Zhujia sluice (C#) | 5                | 18%                              | 144                              | Cangnan county                  | Pingyang county             |
| Meixi Dongyang (D#)               | 2.95               | 11%                              | 88                               | Pingyang county                 | Cangnan county             |

Plan B: The assessment sections were set up in Aojiang river Liming village (B#), Cangnan boundary section of Hengyang branch river (C#) and Meixi Pingyang boundary section (D#). The distribution result of compensation funds is shown in Table 8.

| Assessment river  | Assessment section | Average flow rate of years (m³/s) | Proportion of compensation funds | Fund amount (ten thousand yuan) | Upstream                  | Downstream                  |
|------------------|--------------------|----------------------------------|----------------------------------|---------------------------------|---------------------------|-----------------------------|
| Aojiang main stream | Liming village (B#) | 16.2                             | 67%                              | 536                             | Pingyang county           | Cangnan county              |
| Hengyang tributary Zhujia sluice (C#) | 5                | 21%                              | 168                              | Cangnan county                  | Pingyang county             |
Funds for ecological compensation shall be used exclusively for the adjustment of industrial structure and optimization of industrial layout in the Aojiang river basin, the construction of a water-conserving society, the comprehensive treatment of river basins, the prevention and control of water pollution, the control of soil erosion, and the protection of the ecological environment. No detention, appropriation or misappropriation shall be allowed. If the upstream compensates the downstream, the fund mainly compensates the relevant towns in the downstream area; If the downstream compensates upstream, the fund mainly compensates the relevant towns in the upstream area.

5. Conclusion
Taking the Aojiang river basin in southern Zhejiang as the research object, this paper analyzes the framework system, compensation scope, subject and object, compensation basis, assessment method and accounting method of horizontal ecological compensation between counties. Two horizontal ecological compensation solutions between southern Zhejiang counties are obtained. Plan A: The assessment sections were set up in Aojiang river Xilu village (A-1 #), Cangnan boundary section of Hushan inland river (A-2 #), Cangnan boundary section of Xiaojiangtang river (A-3 #), Cangnan boundary section of Hengyang branch river (C#) and Meixi Pingyang boundary section (D#). The fund allocation ratio was 59%, 6%, 6%, 18% and 11% respectively. Plan B: The assessment sections were set up in Aojiang river Liming village (B#), Cangnan boundary section of Hengyang branch river (C#) and Meixi Pingyang boundary section (D#). The fund allocation ratio was 67%, 21%, 12% respectively. It will provide reference and technical support for Wenzhou to establish a scientific and feasible horizontal ecological compensation mechanism in the upper and lower reaches of the city basin and the left and right banks by 2020.

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