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Research on the Design of Multi-Objective Decision Optimization Model and Legal Suitability in Environmental Legal Dispute Resolution

Wenting Zheng[1,✉]

[1] *School of Humanities and Social Sciences, Dalian Medical University, Dalian, Liaoning, 116044, China*

ABSTRACT

The construction of ecological civilization is a fundamental plan related to the sustainable development of economy and society, and the dispute settlement mechanism of environmental damages is its innovative and important content. Starting from the environmental legal dispute resolution mechanism, the article analyzes the legal basis of environmental dispute mediation and the process related to pre-litigation mediation. Considering environmental legal dispute resolution as a kind of multi-objective decision-making optimization problem, a multi-objective decision-making optimization model for environmental legal disputes is constructed with the objective functions of legal effectiveness, legal applicability and subject interest rate. Then adaptive inertia weights and dynamic image Pareto solution set updating strategy are introduced to improve the multi-objective particle swarm algorithm, and combined with information entropy-based TOPSIS decision-making to realize the optimal solution selection for environmental legal dispute resolution. In the multi-objective decision-making optimization model, the improved multi-objective particle swarm algorithm achieves the optimum for a total of 15 data, and the simulation time in solving the optimal solution of the 10*10*5 case problem is only 2.314s, and the optimal solution of environmental legal dispute resolution can be obtained based on different objective functions. Environmental legal dispute resolution needs to aim at effectiveness, applicability and subject's interests, introduce appropriate punitive damages, realize the effective connection between administrative law and criminal law, and promote the high efficiency of environmental legal dispute resolution.

Keywords: multi-objective decision optimization, adaptive inertia weights, Pareto solution set, environmental legal disputes, multi-objective particle swarms

1. Introduction

In recent years, the rise of environmental problems has triggered various kinds of social conflicts, and

✉ Corresponding author.
E-mail address: 16642706600@163.com (W. Zheng).
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many disputes are not effectively resolved at the early stage of the conflict or are not dealt with in an appropriate way, which has led to the frequent occurrence of mass incidents. Among the many systems for resolving environmental disputes in China, the more widely used is the judicial litigation system, but its procedural requirements are strict and the period is long [1-2]. In the practice of judicial litigation system, environmental disputes between the two parties due to the status and economic strength of the difference between the two parties, the victimized party is reluctant to choose litigation as a last resort. And the government as the environmental managers, law enforcers, in dealing with conflicts and disputes, the use of legal duties and professional power to non-compulsory means of mediation to resolve disputes has achieved better results, showing its unique advantages [3-5]. Low-cost, high-efficiency, dialogical non-confrontational dispute resolution has become an important option for the government to solve environmental disputes [6-7].

Judicial regulation itself implies decision-making, or even is itself decision-making [8]. Decision-making in a broad sense is a process that includes a series of processes such as proposing a decision problem, determining a decision goal, collecting and organizing information, formulating alternatives, analyzing and evaluating options, and choosing a course of action [9-11]. In decision theory, decision makers are often faced with decision problems with multiple objectives. Non-metricity and contradiction between objectives are two distinctive features of multi-objective decision-making problems, i.e., there is no uniform metric for each objective and there is some kind of contradiction between the alternatives among the objectives [12-13]. Multi-objective decision-making method is a method for solving multi-objective decision-making problems, but it cannot find an optimal solution to satisfy all the objectives, which is determined by the characteristics of the problem itself [14-16]. When allocating responsibilities in environmental legal disputes, the judiciary is faced with multidimensional legal values, and the degree of importance between each legal value is different, it is necessary to utilize the multi-objective decision-making method to rank them, in order to make a reasonable allocation result [17].

Constructing a multi-objective decision-making optimization model for environmental legal dispute resolution is conducive to promoting the reform of the diversified dispute resolution mechanism for ecological and environmental damages and promoting the construction of ecological civilization and rule of law. Taking environmental legal dispute resolution as the research objective, the article constructs a multi-objective decision-making optimization model for environmental legal disputes by combining the constraints from the three objectives of legal validity, legal applicability and rate of subject's interests of environmental legal dispute resolution. The multi-objective particle swarm algorithm is introduced to solve the model, the weight coefficients of the algorithm are optimized by adaptive inertia weights, the Pareto solution set updating strategy with dynamic image is combined to obtain more non-dominated solutions in the decision space, and the optimal solution of environmental legal dispute resolution is obtained by the entropy-weighted TOPSIS decision-making method. The effectiveness of the improved multi-objective particle swarm algorithm is verified through simulation, and the legal applicability and optimization path of environmental legal dispute resolution are proposed.

2. Basics of environmental law dispute resolution

In recent years, with the deepening of people's attention to healthy life, the ecological environment as an indispensable part of people's life, its good or bad directly affect people's quality of life and health, people's demand for the ecological environment is increasing, the ecological environmental protection of the understanding of the gradual deepening. With the increased attention to environmental protection, there are many legal provisions applicable to environmental protection, environmental legal disputes through legal means has become the focus of the current research of relevant experts and scholars. Law as an important means of environmental protection, through the construction of law can promote the mediation of environmental legal disputes.

2.1. Environmental courts and dispute resolution mechanisms

2.1.1. Environmental courts and judicial specialization. Specialization of environmental justice refers to the system and process by which environmental cases are heard by environmental courts in accordance with specialized environmental judicial procedures. The core content of environmental judicial specialization is the specialization of environmental judicial subjects, the specialization of judicial procedures and the specialization of judicial objects. In this, environmental court construction is the most important aspect of environmental justice specialization. The construction of environmental courts not only includes the construction of specialized environmental resource trial institutions, but also includes the soundness of legal procedures adapted to the needs of environmental justice, as well as the improvement of support and guarantee mechanisms.

China's environmental courts mainly include four forms. The first is the environmental protection tribunal, i.e., a trial body specializing in environmental cases set up within people's courts at all levels, which may be composed of judges and people with specialized knowledge of environmental protection. Environmental protection tribunals are generally located in areas where environmental problems are more serious or where greater importance is attached to environmental protection. The second type is the Environmental Protection Collegiate Court, which is usually formed on an ad hoc basis to hear environmental cases and consists of three or more specialized judges and jurors. The third type is the Environmental Protection Circuit Court, which is an organization of people selected by the People's Court to travel around the jurisdiction to handle environmental cases. The fourth type is the grass-roots environmental protection courts, which are part of the basic people's courts and are responsible for hearing environmental cases, and are mostly established in areas where the incidence of environmental pollution incidents is high and pollution is more serious.

2.1.2. Framework for environmental dispute resolution mechanisms. Currently, environmental disputes are frequent, and the resolution mechanisms used mainly include direct consultation and negotiation, people's mediation, civil arbitration, administrative mediation, judicial mediation, judicial litigation, round-table dialogues and other legal, administrative or social means [18]. In view of the reality of the large number of environmental disputes, the long-term complexity of the improvement of the judicial system, as well as the status of the main responsibility of the administrative system, the effective resolution of environmental disputes depends not only on the strengthening of the dominant force of the administrative and judicial system, but also on the establishment and improvement of social mechanisms, especially the role of the community and specialized social organizations should be given full play. The framework of environmental dispute resolution mechanisms is shown in Figure 1, with each method of resolution having its own preconditions and scope of application, thus making it impossible to effectively resolve environmental disputes.

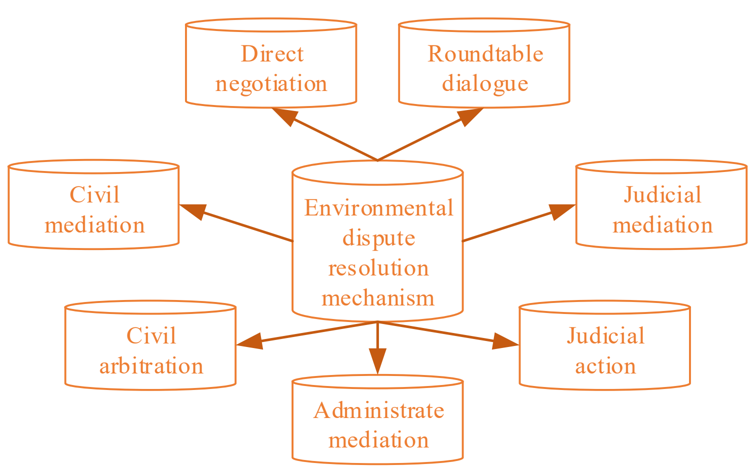


Fig. 1. Framework of environmental dispute settlement mechanism

1) The mechanism of direct consultation and negotiation between the parties has autonomy, is simple and easy to implement, timely and economical, and is helpful in resolving small, life-size environmental disputes, but has limitations in resolving large, complex environmental disputes.
2) People's mediation is characterized by low cost, simplicity and timeliness, which is mostly applicable to the settlement of small-scale life-type environmental disputes, but is not suitable for most complex industrial disputes.
3) Civil arbitration is independent, flexible, economic and professional, and has certain exploration and practice in environmental arbitration, but it needs to be established and perfected in terms of system and institution.
4) Administrative mediation has both professional and technical advantages, can meet the public's administrative preferences, and is one of the main ways to solve environmental disputes, but the relevant provisions on administrative mediation need to be further refined and clarified.
5) Judicial mediation has a certain quasi-judicial, and the mechanism of flexible operation, not only can resolve some of the environmental disputes, but also ease the pressure of litigation, but in the mechanism design should be more scientific and standardized.
6) Judicial litigation is the most standardized and authoritative method to solve environmental disputes, and it is the last barrier to safeguard the rights and interests of the parties, but there is still a lot of room for improvement in the environmental litigation system and mechanism.
7) The stakeholder round-table dialogue mechanism is feasible, effective and low-cost in resolving environmental disputes, and it is especially suitable for resolving complex environmental disputes with multiple stakeholders, but the mechanism itself needs to be further standardized.

2.2. Pre-litigation mediation for environmental dispute resolution

2.2.1. Legal basis for mediation in environmental disputes. The legal basis for environmental administrative conciliation is mainly article 41 of the Environmental Protection Law, which states: “Anyone who causes harm by environmental pollution has the responsibility to remove the harm and compensate the unit or individual who has been directly harmed. Disputes over liability and the amount of compensation may, at the request of the parties concerned, be handled by the administrative department in charge of environmental protection or other departments exercising environmental supervision and management in accordance with the provisions of the law. If the parties concerned are not satisfied with the handling decision, they may sue in the people's court, and the parties concerned may also sue directly in the people's court.”

The legal basis of administrative mediation is more difficult than that of traditional administrative law, such as administrative penalties, administrative licenses, administrative coercion and administrative legislation. Because administrative mediation from the object of both civil disputes and administrative disputes. Moreover, in addition to the legal basis of administrative mediation, in practice, there are a large number of different forms of mediation hosted by the administrative organs or led by the mediation, some eventually formed a mediation agreement, some on-site settlement. Administrative mediation is also not a single form [19]. Functionally, administrative mediation has the role of both alternative litigation, reconsideration, arbitration, as well as other administrative behavior. From the motive and effect, administrative organs use mediation method, early intervention in dispute resolution, flexible use of multiple means to achieve the administrative management objectives, saving administrative expenses and the cost of the parties and time costs, should be encouraged. However, from the point of view of opposing and guarding against the involvement of administrative organs in civil disputes, administrative organs must resolve civil disputes in accordance with the principle of voluntariness of the parties concerned and avoid excessive interference by public power in civil disputes. Although administrative mediation ultimately leads to the consent of the parties, should be relying on the administrative organs in the professional and other issues of the advantages and administrative authority, and can not force the parties to receive mediation agreement. However, it is conceivable that the coercive power of the administrative organ as a background has a deterrent and influence on the parties, especially in administrative disputes, where the administrative organ as the moderator of administrative conciliation still has a great influence on the parties.

2.2.2. Pre-litigation mediation for environmental dispute resolution. After the introduction of pre-litigation mediation in environmental litigation cases, the non-litigation dispute resolution body conducts mediation with reference to litigation procedures. Only if the dispute is still not resolved within 30 working days can it be transferred back to the litigation mode, and if it is not within the stipulated time limit, it shall not be returned at will, so as to avoid the problem of transferring back arbitrarily by the pre-litigation mediation committee for environmental civil disputes. Environmental dispute litigation pre-litigation mediation process is shown in Figure 2. For the reversal of litigation, the non-litigation dispute resolution agency shall issue the reasons and explanations for not resolving the dispute. This is to provide a route for cases that have not been resolved through non-litigation or are not suitable for non-litigation dispute resolution, and to avoid non-litigation dispute resolution becoming a mere formality due to the lack of control over the exit. In the case of successful pre-litigation conciliation in environmental litigation, the pre-litigation conciliation agreement can be judicially recognized upon application by the parties, so as to make the pre-litigation conciliation agreement in environmental litigation legally binding.

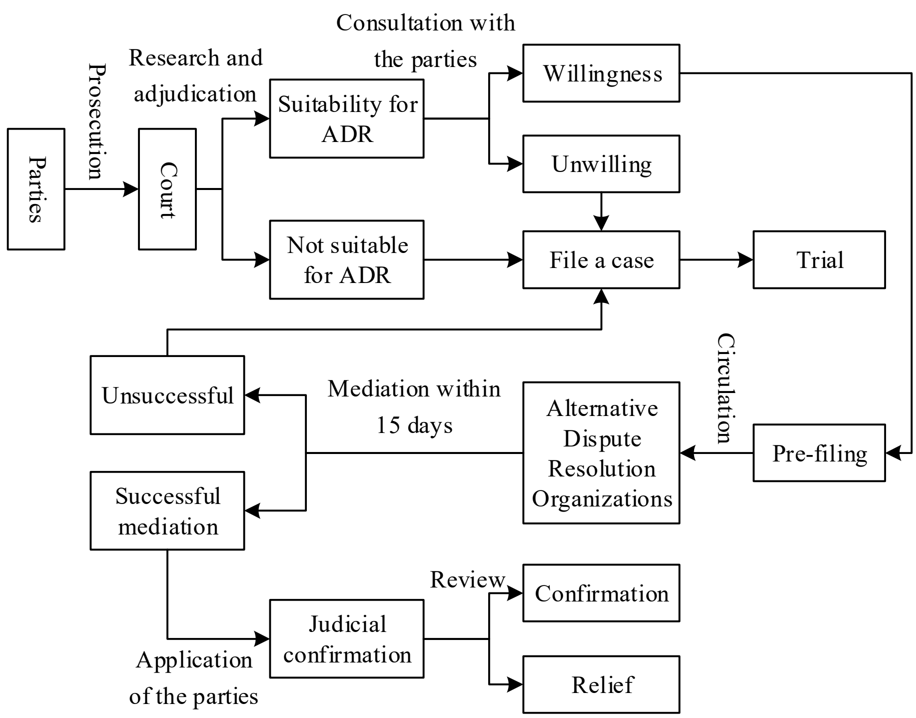


Fig. 2. The environmental dispute solves the pre-mediation process

After a case has been transferred to an environmental non-litigation dispute resolution body comprising the Government, relevant environmental protection departments and others to carry out pre-litigation mediation, the court should provide the necessary supervision and guidance to the non-litigation dispute resolution body in mediating environmental litigation cases, as its rules are relatively weak. Given that litigation service centers are increasingly being asked to assume public legal service functions in the process of upgrading, pre-litigation mediation committees for environmental disputes can work in the non-litigation special zone studios set up in litigation service centers to regulate the mediation process and behavior. In addition, before referring a case for pre-litigation mediation, the judge must clarify the focus of the dispute and fix the evidentiary materials, in order to provide the necessary guidance on pre-litigation mediation in environmental litigation, and to actively promote a mediation agreement between the parties.

3. Multi-objective decision-making optimization model for environmental legal disputes

Pre-litigation mediation, with its advantages of efficiency and flexibility, low cost, fairness and impartiality, has gradually become an effective way of resolving environmental legal disputes and plays an important role in promoting economic and social development. Pre-litigation mediation, arbitration, consultation and litigation can all resolve disputes over ecological and environmental damages, but in terms of process efficiency and technical expertise, pre-litigation mediation shows its own unique value. Pre-litigation mediation needs to comprehensively consider the interests of multiple subjects to realize the solution of environmental legal disputes with the optimal program. Thus, it is necessary to construct a multi-objective decision-making optimization model for environmental legal disputes.

3.1. Multi-targeted environmental legal disputes

3.1.1. Multi-objective optimization problems. Taking minimization as an example, a multi-objective optimization problem can be defined as:

$$\min F(x) = \left[f_1(x), f_2(x), \ldots, f_m(x)\right]^T, x \in \Omega \tag{1}$$

where $x = \left[x_1, x_2, \ldots, x_n\right]$ is the n-dimensional decision variable, Ω is the decision space, $f(x)$ is the m-dimensional objective function, and $m > 1$, $fm(x)$ denote the mth objective function [20]. Typically, solutions are compared using the Pareto dominance relation, where one solution x Pareto dominates another solution $y(xpy)$, i.e:

$$\begin{gathered} \forall i : f_i(x) \le f_i(y), \exists j : f_j(x) < f_j(y) \\ s.t. i = 1, \ldots, m, j = 1, \ldots, m \end{gathered} \tag{2}$$

In the multi-objective optimization problem, the solution that is not dominated by any other solution is called the non-dominated solution or Pareto-optimal solution, and the mapping of the set of Pareto-optimal solutions in the objective space is called the Pareto frontier (PF).

For the research content of this paper, it is mainly expressed as the correlation of interests between various subjects of environmental legal disputes, and it is necessary to maximize the interests of various subjects on the basis of solving environmental legal disputes, and it is also necessary to obtain the optimal solution of environmental legal disputes based on the results of multi-objective solving.

3.1.2. Objective function establishment:

1) Legal effectiveness. The number of environmental legal provisions not only reflects the government's attention to environmental laws, but also reflects the government's awareness of environmental protection. Therefore, the number of environmental legal provisions currently in existence is used as an evaluation index of legal validity to adjust legal relations and ensure that environmental legal provisions maintain a balance of validity before and after implementation. Firstly, the mathematical model of the number of environmental legal provisions is established according to the government's attention to environmental laws, namely:

$$Q_{fc} = \int_0^t b_e\left(w_e(i), T_e(i)\right) di \tag{3}$$

As a result, the mathematical model of the evaluation indicators of legal effectiveness is obtained and can be expressed as follows:

$$f_1(x) = Q_{fc}(x) \tag{4}$$

In the formula, $f_1(x)$ is the evaluation index of legal effectiveness, $Q_{fc}(x)$ is the number of environmental legal provisions, b_e is the implementation rate of environmental legal provisions, w_e is the time of introduction of environmental laws, and T_e is the degree of importance attached by the government to environmental laws.

2) Legal applicability. The applicability of the law mainly refers to the implementation of environmental law can better help to solve the environmental legal disputes, if the optimal application is not realized, it may not be able to solve the environmental legal disputes in a timely and effective manner. Based on this, this paper starts from the upper limit value of legal applicability and gets the expression of maximum legal applicability as:

$$j = \frac{da}{dt} = \frac{du_a}{dt^2} \tag{5}$$

$$f_2(x) = \max\{|j|\} \tag{6}$$

Where j is the legal effectiveness, a is the effect of environmental law implementation, and t is the time of environmental law implementation.

3) Rate of subject's interest. The purpose of the law is to ensure the optimal interests of the subjects on the basis of the appropriate legal provisions to achieve fairness and justice. The greatest impact on the subject's interests is the number of administrative review cases of environmental disputes. Therefore, the number of administrative review cases of environmental disputes from 0 to 500 cases is taken as the index of subject's interestability:

$$f_3(x) = \int_{t_0}^{t_{100}} dt = \int_0^{100} \frac{1}{a} du_a = \int_0^{100} \frac{\delta m}{F_t - \left(F_f + F_w\right)} du_a \tag{7}$$

where $f_3(x)$ is the subject interest rate.

In summary, the multi-objective decision optimization mathematical model of environmental legal disputes is obtained which can be expressed as:

$$\begin{cases} \max\ y = F(x) = \left(f_1(x), f_2(x), f_3(x)\right) \\ f_1(x) = Q_{fc}(x) \\ f_2(x) = \max\{|j|\} \\ f_3(x) = \int_0^{100} \frac{1}{a} du_a \\ s.t. g_j \le 0, j = 1, 2, \cdots, J \\ h_k(x) = 0, k = 1, 2, \cdots, K \end{cases} \tag{8}$$

3.1.3. Constraint setting:

1) Legal balance constraint. Environmental law disputes in the resolution process will not only refer to the relevant provisions of environmental law, but also by the influence of other legal provisions, this paper proposes legal balance constraints to control the influence of other legal provisions. This paper proposes the legal balance constraint to control the influence of other legal provisions:

$$p_{law}(t) + \sum_{i=1}^{N_{body}} p_{body,i}(t) + \sum_{j=1}^{N_{law}} p_{law,j}(t) = p_{load}(t) + p_{loss}(t) \tag{9}$$

Where $p_{law}(t)$ for the effectiveness of the implementation of environmental law at the moment of t, N_{body}, N_{law} are the number of subjects of the negotiated settlement and the number of legal provisions, $p_{body,i}(t)$ for the i th subject in the legal claims at the moment of t, $p_{law,j}(t)$ for the validity of the legal provisions of the j th at the moment of t, $p_{load}(t)$, $p_{loss}(t)$ are the total load and the total loss of the implementation of environmental law provisions at the moment of t, respectively.
2) Environmental law implementation time constraint, then:

$$\begin{cases} p_{law,j}^{\min} \le p_{law,j}(t) \le p_{law,j}^{\max} \\ if\ p_{law,j}(t) \le 0 \\ E_{body,j}(t) = E_{body,j}(t-1)(1-\delta) + p_{body,j}(t)\eta_c \Delta t \\ if\ p_{body,j}(t) > 0 \\ E_{law,j}(t) = E_{law,j}(t-1)(1-\delta) - \dfrac{p_{law,j}(t)}{\eta_d}\Delta t \\ 0.15 \le LAW_j(t) \le 0.95 \\ LAW_j(0) = 0.55 \\ \sum_{t=1}^{T}\left[p_{body,j}(t) a_1 \eta_c + p_{law,j}(t)\dfrac{a_2}{\eta_d} \right]\Delta t = 0 \end{cases} \tag{10}$$

Where: $p_{law,j}^{\max}$, $p_{law,j}^{\min}$ for the implementation of environmental legal provisions of Article j, respectively, the upper and lower limits of efficiency, $E_{law,j}(t)$ for the t moment environmental legal provisions of the efficiency of j, δ for the legal provisions of the effective index, η_c, η_d, respectively, for the implementation of environmental legal provisions. $LAW_j(t)$ for t moments of the implementation of legal provisions j state, in order to prevent excessive implementation of legal provisions to affect the fairness, set its range from 0.15 to 0.95, and in the beginning and end of an implementation cycle are maintained at 0.55. a_1, a_2 that the implementation of environmental legal provisions of the implementation of the state when $p_{law,j}(t) \le 0$ when the implementation of the law, $a_1 = 1$, $a_2 = 0$, when $p_{law,j}(t) > 0$ when the environmental law is not implemented, $a_1 = 0$, $a_2 = 1$.

3.2. Multi-objective decision optimization model solving

3.2.1. Multi-objective particle swarm algorithm. In multi-objective particle algorithms, each particle has two attributes, velocity and position. Where the position of each particle is a potential solution to guide the flight of the particle and update its position by utilizing the individual historical best position of the particle and the global best position of the population. The mathematical model of multi-objective particle algorithm is described as follows:

Assume that the population size is N and search in D-dimensional space. So at the t rd iteration, the velocity and position of particle i in D-dimensional space are $v_i = (v_{i1}, v_{i2}, \ldots, v_{iD})$ and $x_i = (x_{i1}, x_{i2}, \ldots, x_{iD})$ respectively. the velocity update formula of particle i consists of three parts, the first part is an inheritance of the particle to the historical velocity, the second part is the tendency of the particle to the individual's best direction so far, where the individual's best value so far is called the individual's extreme value, and the third part is the tendency of the particle's flight to the global optimal direction. So the flight of the particle in the next time is determined based on the combination of the above three directions [21]. The velocity and position update equations are expressed as respectively:

$$v_{id}(t+1) = wv_{id}(t) + c_1 r_1 \left(pbest_{id}(t) - x_{id}(t) \right) \\ + c_2 r_2 \left(gbest_{id}(t) - x_{id}(t) \right) \tag{11}$$

$$x_{id}(t+1) = x_{id}(t) + v_{id}(t+1) \tag{12}$$

where v_{id} denotes the velocity of the i nd particle in the d rd dimension, w denotes the inertia weight, $pbest_{id}$ denotes the individual extreme value learned by the i th particle in the d th dimension, $gbest_{id}$ denotes the global optimum value learned by the i th particle in the d th dimension, and x_{id} denotes the position of the i th particle in the d th dimension. In addition, c_1, c_2 are acceleration constants. r_1, r_2 are random numbers distributed between $[0,1]$.

The general steps of the multi-objective particle swarm algorithm are as follows:

Step1 Initialize the population and randomly initialize the velocity and position of each particle in the population.

Step2 Calculate the objective function value of each particle in the population.

Step3 According to Pareto domination principle, store the non-dominated solution set into the archive.

Step4 Update and maintain the archive.

Step5 Judge whether the algorithm satisfies the output condition, if it satisfies the end condition, the algorithm ends. Otherwise, go to the next step.

Step6 Calculate the individual historical best position and the global best position of the population.

Step7 Update the velocity and position of each particle in the population, and make the position of the particle equal to the boundary of the search space if it is beyond the search space. Then return to Step2.

3.2.2. Improved multi-objective particle swarm algorithm. In this paper, a multi-objective optimization problem is proposed, which contains continuous and integer variables in the decision variables, quadratic objective function, and the constraints are mostly nonlinear functions, which makes the overall solution difficult. Converting the multi-objective function into a single objective and using the multi-objective particle swarm optimization algorithm can effectively ensure its convergence and global search ability. Since the multi-objective particle swarm algorithm is easy to fall into local optimization when solving multi-objective problems, it is improved to improve the overall computational efficiency.

The position and velocity update formula of the multi-objective PSO algorithm is:

$$v_{ij}(t+1) = wv_{ij}(t) + c_1 r_1 \left[p_{beet,ij}(t) - x_{ij}(t) \right] \\ + c_2 r_2 \left[g_{best,ij}(t) - x_{ij}(t) \right] \tag{13}$$

$$x_{ij}(t+1) = x_{ij}(t) + v_{ij}(t+1) \tag{14}$$

Where $v_{ij}(t)$, $v_{ij}(t+1)$ is the velocity at t and $t+1$ moments, c_1, c_2 is the individual learning factor and social learning factor, w is the inertia weight of the velocity, and $x_{ij}(t)$ is the position of the particle at t moments. $p_{best,ij}(t)$, $g_{best,ij}(t)$ are the best position of the d th iteration where i particles pass through and the best position of the d th iteration where all particles pass through, and j is the dimension of the search space.

The inertia weight w reflects the degree to which the particle inherits the previous moment's moving speed, a larger inertia weight is favorable to the global search, while a smaller inertia weight is more favorable to the local search. In the multi-objective PSO algorithm, the weights are often made to be a fixed value, which is easy to be trapped in the local optimization, and w lacks effective guidance. Therefore, this paper proposes an improved multi-objective particle swarm algorithm based on adaptive inertia weights to optimize the weight settings of multi-objective particle swarm through adaptive inertia weights.

The improved multi-objective PSO algorithm improves w by comparing the degree of difference between the particle positions and the global optimum. When the difference between the two is large, the value of w needs to be increased to ensure its global search ability; on the contrary, the value of w is decreased to make it have better local search ability. The specific calculation process is as follows:

$$w_i^d = \begin{cases} w_{\min} + \left(w_{\max} - w_{\min}\right) \times \\ \dfrac{f\left(x_i^d\right) - f_{\min}^d}{f_{average}^d - f_{\min}^d} & f\left(x_i^d\right) \le f_{average}^d \\ w_{\max} & f\left(x_i^d\right) \le f_{average}^d \end{cases} \tag{15}$$

$$f_{average}^d = \sum_{i=1}^{n} f\left(x_i^d\right) \Big/ n \tag{16}$$

$$f_{\max}^d = \max\left\{ f\left(x_1^d\right), f\left(x_2^d\right), \cdots, f\left(x_n^d\right) \right\} \tag{17}$$

Where $w_{\min}$, $w_{\max}$ are the preset minimum and maximum inertia weights, $f_{average}^d$ is the average adaptation degree of all particles in the d th iteration, and $f_{\max}^d$ is the maximum adaptation degree of all particles in the d th iteration.

Considering the differences of the three objective functions and judgment criteria, it is necessary to normalize $f_{\max}^d - f\left(x_n^d\right)$ and standardize $f\left(x_n^d\right) \Big/ \sqrt{\sum_{i=1}^{n} f^2\left(x_n^d\right)}$ to convert the three objective functions with different criteria into a single objective function.

3.2.3. Pareto Solution Set Updates and Global Optimization:

1) Pareto solution set updating method. In the initial particle distribution stage, all the particles of the original comparison rule are referred to, and an image is created with the optimal Pareto solution set as the optimal particle among them. As the iteration proceeds, the average value of the particles is obtained between every two images, and the optimal solution is used as the global optimum at this moment so that the particle velocity and position can be updated to make the particle population travel in the direction of the target [22]. Throughout the process, the new particles continuously exchange information with the image particles and uninterruptedly update the data in the image particles until the termination of the iteration. The maximum number of iterations is specified as the basis for convergence, and if the convergence criterion is satisfied, the results are output, otherwise the particle positions and velocities are updated according to the formula, viz:

$$\begin{aligned} v_{iD}^{t+1} &= w v_{iD}^{t+1} + c_1 rand_1 \left(p_{iD} - x_{iD}^{t+1}\right) \\ &\quad + c_2 rand_2 \left[Average\left(p_{best_p}^{p}\right) - x_{iD}^{t} \right] \end{aligned} \tag{18}$$

$$x_{iD}^{t+1} = x_{iD}^{k} + v_{iD}^{k+1} \tag{19}$$

Where t is the number of iterations, D is the number of dimensions of the decision variable, p_{iD} is the best historical value of a single i particle, p_{best_p} is the current optimal particle of the Pareto solution set in the image, and $Average\left(p_{best_p}\right)$ is the better particle of the optimal Pareto solution set of the two images. When the particles are updated to a later stage, in order to avoid repeated updates of the same particle, a random number generator is introduced to make the particles complete the search as soon as possible. Randomly selected from the top 20% Pareto solutions with larger dense distances are used to guide the particle swarm update.

2) Multi-attribute decision making based on TOPSIS method. In this paper, the information entropy based TOPSIS method is used, which consists of the optimal solutions in the Pareto solution set to form N alternatives $X_1 \sim X_N$, and scheme X_i is selected from N filed. $g_m\left(X_i\right)$ represents the mth attribute value of option X_i, which should be unified and changed to the same type due to the variability of each attribute. The new attribute value is $G_m\left(X_i\right)$ for:

$$G_m\left(X_i\right)=\frac{g_m\left(X_i\right)}{\sqrt{\frac{1}{N}\sum_{i=1}^{N} g_m^2\left(X_i\right)}} \tag{20}$$

The information entropy method is chosen to determine the weight of each objective value, which improves the precision of the final decision, reduces the variability, and then obtains the optimal solution for environmental legal dispute resolution.

3.2.4. Improved Particle Swarm Algorithm Solution Procedure. Combined with the previous multi-objective problem of environmental legal disputes, the improved multi-objective particle swarm algorithm is applied to the solution of this multi-objective problem. The specific steps are as follows:

Step1 Set the parameters of multi-objective particle swarm algorithm and import the parameters of multi-objective optimization of environmental legal dispute.

Step2 Initialize each decision variable.

Step3 Initialize the historical optimal solution and the global optimal solution.

Step4 Judge the desired direction of environmental legal solution according to the subject information, and use it to guide the performance of environmental legal disputes in each time period.

Step5 Calculate the inertia weight, update the speed, and judge whether the particle evolution direction needs to be corrected, if not, then directly proceed to Step7, if it needs to be corrected, then proceed to Step6.

Step6 Direct the particle evolution direction based on the body information.

Step7 Update the position of the particle.

Step8 Update the global optimal solution and historical optimal solution.

Step9 Determine whether the maximum number of iterations has been reached, if not, go to Step5, if the maximum number of iterations has been reached, perform the next step.

Step10 Use TOPSIS method to establish the optimal solution for resolving environmental legal disputes.

4. Optimization of multi-objective decision-making and legal applicability in environmental legal disputes

With the development of industry and science and technology, the ecological environment has suffered more and more serious damage, according to the “principle of liability for damage”, the responsible person must repair or compensate for the damaged ecological environment. In the face of the ecological environment damage disputes are rising year by year, due to the high cost of litigation, long time, and there is administrative law enforcement and other dilemmas, negotiation as the first choice of the parties to the dispute, the most flexible, the most simple non-litigation dispute resolution gradually become an important way to deal with the ecological environment damage compensation disputes. And in the process of environmental legal dispute resolution to fully guarantee the interests of all parties to realize the effectiveness of environmental law has become an urgent problem to be solved.

4.1. *Multi-objective decision optimization model solving*

4.1.1. Improving validity verification. In order to verify the effectiveness of the multi-objective particle swarm algorithm improved by adaptive inertia weights in this paper, PSO, GA-PSO, NGA-PSO and this paper's algorithm are selected for comparison, 10 different cases are designed, and each algorithm is run for 15 times for each case, and the IGD and average HV of each algorithm are recorded.HV is used for evaluating the diversity of the nondominated solution sets, and the larger the value, the wider the coverage of the solution sets in the objective space. HV is used to evaluate the diversity of the non-dominated solution sets, the larger the HV value, the wider the coverage of the solution sets in the objective space.IGD is used to evaluate the convergence of the multi-objective optimization algorithms, comparing the distance between the approximate non-dominated solution sets generated by the multi-objective optimization algorithms and the real non-dominated solution sets.The smaller the value of the IGD is, the closer the distance between the solution sets generated by the algorithms and the real solution sets, which indicates that the algorithm of the class has a better convergence performance. The results of the average HV and IGD values of different algorithms are shown in Table 1, where the scale values are the number of environmental legal provisions, the number of subjects involved in the consultation, and the number of consultation groups, and the bolded values are the better values of the algorithm.

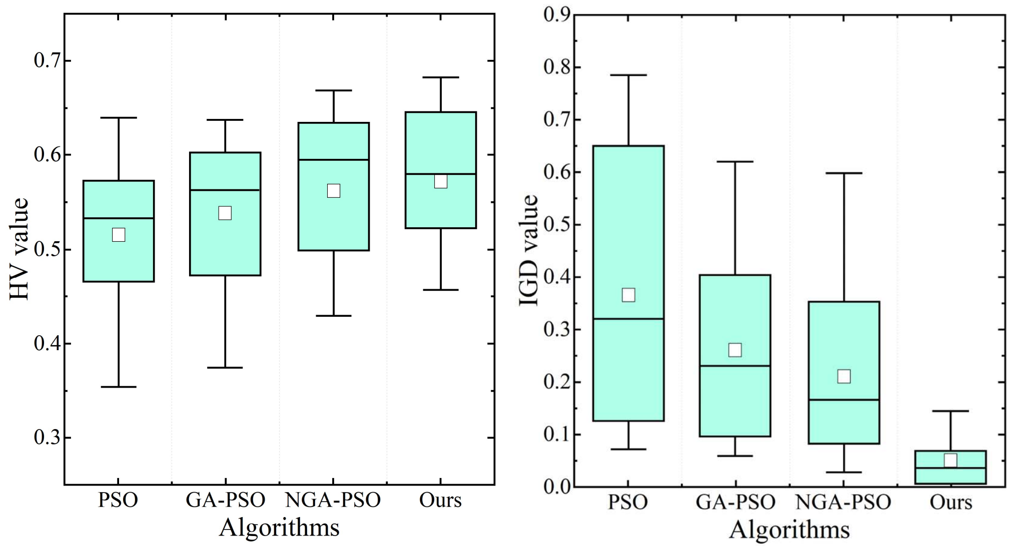
Based on the bolded data in the table, it can be seen that the multi-objective particle swarm algorithm improved based on adaptive inertia weights in this paper achieves the optimization of a total of 15 data under the two indexes of HV and IGD, while there is no bolded data in the PSO algorithm. This fully demonstrates that the improved multi-objective particle swarm algorithm designed in this paper significantly outperforms the traditional PSO algorithm in both convergence and diversity. In addition, combining the results of this paper and PSO algorithm, it can be seen that the addition of adaptive inertia weights and the dynamic image Pareto solution set updating method can help to produce better non-dominated solution sets, which can significantly improve the diversity of the solution sets, and can also effectively guide the evolution of the population.

Table 1. Comparison of results of four algorithms

Example	Scale	HV				IGD			
		PSO	GA-PSO	NGA-PSO	Ours	PSO	GA-PSO	NGA-PSO	Ours
HJF01	10*6*3	0.546	0.468	0.611	0.596	0.125	0.095	0.079	0.018
HJF02	10*6*3	0.459	0.504	0.452	0.532	0.489	0.301	0.165	0.005
HJF03	15*9*5	0.532	0.639	0.637	0.697	0.302	0.216	0.169	0.061
HJF04	15*9*5	0.678	0.665	0.705	0.724	0.115	0.093	0.091	0.008
HJF05	15*6*5	0.587	0.626	0.669	0.679	0.069	0.057	0.023	0.035
HJF06	10*15*3	0.319	0.346	0.505	0.495	0.654	0.615	0.894	0.103
HJF07	20*5*5	0.482	0.457	0.416	0.531	0.336	0.238	0.153	0.006
HJF08	20*10*5	0.575	0.602	0.598	0.604	0.123	0.075	0.051	0.045
HJF09	20*10*5	0.436	0.568	0.492	0.451	0.647	0.489	0.347	0.128
HJF10	20*15*5	0.594	0.593	0.665	0.657	0.778	0.395	0.382	0.005

In order to further compare the HV and IGD indicators of different algorithms, the box plots of four different algorithms are compared and analyzed, and Fig. 3 shows the results of the comparison of the box plots of different algorithms, in which Fig. 3(a)~(b) shows the results of the comparison of the HV and IGD indicators, respectively. As can be seen from the figure, in the first three algorithms, the median and the mean of the HV indicator show a step-up trend, and the median of the HV of the algorithm in this paper has a slight decrease, but its HV mean is improved. This indicates that the diversity of the algorithms is improved after the introduction of adaptive inertia weights and the

Pareto solution set updating strategy for dynamic images. Combined with the trend of IGD values, the four algorithms have an obvious decreasing trend in IGD values, which indicates that each improvement strategy can effectively improve the convergence of the original particle swarm algorithm, and the convergence of this paper's algorithm is relatively stronger.



(a) HV (b) IGD

Fig. 3. Comparison of box charts for different algorithms

4.1.2. Change in the value of the objective function. In order to further verify the feasibility and superiority of the improved multi-objective particle swarm algorithm in this paper, for the solution of multi-objective decision optimization problems, this paper chooses PSO-SA algorithm and NGA-PSO algorithm for comparison, and three typical cases are used for testing, whose problem sizes are 10*10*5, 15*10*5, and 15*10*10, respectively, and the running results of the solution are recorded,. The comparison of the running results obtained for solving the typical problems is shown in Table 2, and Fig. 4 shows the variation of the optimization objective obtained by solving the 10*10*5 case using the method of this paper.

As can be seen from Figure 4, the algorithm used in this paper converges quickly at the beginning of the phase, and has converged to the optimal solution in the early iteration number, which verifies the global search capability of the improved multi-objective particle swarm algorithm based on adaptive inertia weights and dynamic image Pareto. From the table, it can be seen that the improved multi-objective particle swarm algorithm in this paper achieves better results relative to the NGA-PSO algorithm in the value of objective function f3 under the premise that the objective function f1 and f2 must be certain. The simulation time of this paper's algorithm in solving the optimal solution of the 10*10*5 case problem is only 2.314s, which is 10.03% shorter than that of NGA-PSO in the case of obtaining the same maximum completion time, which indicates that the multi-objective example full algorithm based on the adaptive inertia weights and the dynamic image Pareto improved in the search for optimal time is relatively fast, and also indicates that it has a strong ability of local search. And through the change of the objective function value, it can be seen that the stability of this paper's algorithm is stronger, and the improved multi-objective particle swarm algorithm not only improves its global search ability, but also has more excellent robust performance.

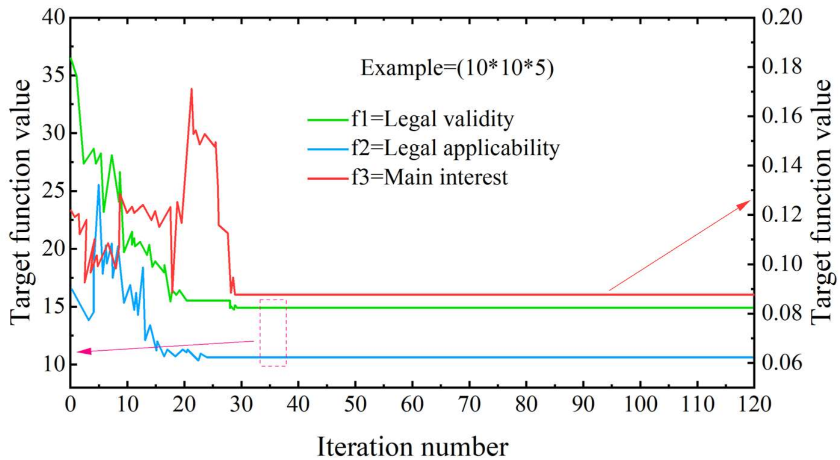


Fig. 4. The target change diagram for solving the case problem

Table 2. Compare the operational results of the typical problem

Example	Target function	Ours		PSO-SA		NGA-PSO	
		Result	Time(s)	Result	Time(s)	Result	Time(s)
10*10*5	f1	15	2.314	17	8.493	17	2.572
	f2	12		12		14	
	f3	0.094		0.151		None	
15*10*5	f1	10	2.385	8	15.668	9	4.995
	f2	6		8		6	
	f3	0.051		0.184		None	
15*10*10	f1	12	5.276	12	None	12	None
	f2	11		None		None	
	f3	0.238		None		None	

4.1.3. Comparison of different programs. In order to verify the necessity and superiority of the improved multi-objective particle swarm algorithm in solving the multi-objective decision-making optimization model for environmental legal disputes, this paper designs 2 groups of experiments for cross-comparison verification:

1) In order to verify the necessity of the three objective functions of the number of environmental legal provisions (O1), the implementation time of environmental laws (O2) and the number of subjects involved in dispute mediation (O3), Programs A~C are designed, all of which use the improved multi-objective particle swarm algorithm for multi-objective decision-making optimization, and analyze the three objective functions in different combinations. Scenario A adopts environmental law provisions for interpretation, while Scenario B introduces environmental law applicability on the basis of Scenario A, and Scenario C introduces the rate of subject's interest based on Scenario B for comparison.

2) In order to further verify the superiority of the improved multi-objective particle swarm algorithm, Scenarios D~F are designed to optimize the decision-making using the traditional PSO algorithm, GA-PSO algorithm and NGA-PSO algorithm, respectively.

The comparison results of the system operating parameters under different schemes are shown in Table 3.

As can be seen from the table, the number of environmental law provisions, the implementation time of environmental law and the number of subjects involved in dispute mediation are all introduced in Scheme C. The legal effectiveness (f1), legal applicability (f2) and the rate of subject's interest (f3) are all gradually improved. And compared with Program A, the legal validity, legal applicability and subject interest rate of Program C are increased by 1.67 times, 4.54 times and 4.81 times respectively.

This shows that the multi-objective decision-making optimization problem of environmental legal disputes can not be separated from the effective support of the number of environmental legal provisions and the implementation time of environmental law, and the interests of the main body need to be taken into account when solving the corresponding environmental legal disputes. It needs to be interpreted and solved by the relevant provisions of the environmental law on the basis of not harming the interests of all parties, so as to better reduce the unnecessary damage caused by the environmental legal disputes. In addition, from the configuration of scheme C~F, the multi-objective particle swarm algorithm based on adaptive inertia weights and dynamic image Pareto solution set performs better in solving the multi-objective decision optimization model of environmental legal disputes, which can fully satisfy the interests of all the subjects and contribute to the stable implementation of the validity and applicability of the environmental law provisions.

Table 3. The system running parameters in different schemes is compared

Scheme	O1	O2	O3	f1	f2	f3
A	√	-	-	18	13	0.154
B	√	√	-	27	28	0.316
C	√	√	√	48	72	0.895
D	√	√	√	26	32	0.247
E	√	√	√	35	49	0.428
F	√	√	√	41	58	0.639

4.2. Applicability of environmental legal dispute resolution

4.2.1. Applicability of punitive damages. In the solution results of the multi-objective decision-making optimization model based on environmental legal disputes, it emphasizes the number of environmental legal provisions implemented, the implementation time and the number of relevant subjects involved in coordinated development. However, in some cases of ecological and environmental legal disputes, there are punitive damages related trial standards, which need to explain the applicability of punitive damages in environmental legal disputes. Specifically as follows:

1) Behavioral elements. First, the behavioral element of liability is met when the tortfeasor commits an act of environmental aggression in violation of the law. Since all types of environmental protection laws and special laws can be applied to ecological and environmental disputes, the scope of “legal provisions” is further clarified, and the people's courts may refer to the relevant provisions of the regulations when necessary, in addition to the laws and regulations as the basis for adjudicating cases of environmental disputes.

2) Subjective element. Second, the tortfeasor must be in a “willful” state of mind in order to satisfy the subjective element of liability. List the factors to be taken into account by the court in determining the “willfulness” of the infringer, including the professional experience and study background of the responsible party. At the same time, in combination with the provisions of the separate law on environmental protection, the special law on environmental protection and other relevant laws, nine situations in which the court should determine that the infringer is "intentional" when hearing environmental dispute cases can be divided into two modes, one of which is the "knowing + implementing" model, which is mainly manifested in the fact that the infringer still carries out the act when he knows that his own behavior will pollute the environment and damage the ecology. The second is the "knowing + laissez-faire" model, which is mainly manifested in the fact that the infringer knows that his act has the possibility of polluting the environment and destroying the ecology, but continues to carry out the act with the mentality of letting the result occur.

3) Consequential elements. As a type of aggravated liability to deter unlawful acts and penalize infringers, punitive liability has a stricter consequence element than liability for damages, which is

aimed at compensating the victim's loss, i.e., it is stipulated that the environmental infringement “causes serious consequences”. In the trial of environmental infringement disputes, the determination of "serious consequences" can be judged based on factors such as the duration of the damage caused by the environmental infringement and the regional scope, and it is clearly stipulated that the loss of life, major infringement of health, and major damage to property shall be regarded as "serious consequences".

4.2.2. Interface between administrative and criminal law. Even though the principle of the applicability of punitive damages in environmental legal disputes has been clarified, there are still some subjects who disregard the results of their hearings on environmental legal disputes. Based on this, it is necessary to give full consideration to the close connection between the administrative sector and the judicial sector in the work of environmental protection. Therefore, to further strengthen the connection between administrative law and criminal law, belongs to the environmental protection work is very important legal application problems, at the same time has great significance.

First of all, through the administrative law and criminal law connection can better strengthen the supervision system of environmental protection work. In environmental protection, administrative law has the characteristics of initiative and advancement, but in reality, some areas of government agencies may be the pursuit of economic interests, but ignored the ecological environmental protection work, thus causing great environmental pollution and ecological damage. By linking these two laws, the supervision of the judicial organs against the law enforcement organs can be strengthened, and the environmental protection work of the administrative law enforcement departments can be strengthened.

Secondly, the interface between administrative law and criminal law can better promote the implementation of judicial means in environmental protection work and give full play to the institutional value of the judicial system. Can greatly expand the source of criminal cases, will have some serious cases transferred to the judicial organs, so as to better combat environmental crime.

Again, through the administrative law and criminal law convergence can be better power constraints. Through the convergence of administrative law and criminal law can strengthen the supervision of the procuratorial organs on environmental protection cases, to carry out more detailed supervision. Through the connection between the two laws, it can strengthen the supervision of the law enforcement departments and also strengthen the supervision of the judicial organs, so as to restrain the power in all aspects.

Finally, through the convergence of administrative law and criminal law can better combat environmental pollution and ecological damage, and constantly strengthen the national ecological environment construction, so as to improve the quality of life of the people of the country, and promote the overall economic and social development of the country. To constantly strengthen the link between law enforcement and judicial departments, to effectively combat all kinds of environmental protection cases, so as to enhance the strength of the fight against environmental protection.

4.3. Optimized Path to Environmental Legal Dispute Resolution

4.3.1. Enhanced design of the Environment Court. At the macro level, strengthening the top-level design of environmental tribunals requires attention to the legitimacy, unity, legality and standardization of the establishment of environmental tribunals, and only through the realization of the four fits can we promote the positive development of environmental tribunals in practice. In response to the characteristics of the environmental justice reform process, the establishment of environmental tribunals is linked to the internal governance needs of the court, the court's trial needs, and thus question the legitimacy of the establishment of environmental tribunals. The setting up of environmental tribunals will undoubtedly have a certain impact on the internal position setting of the courts, such as changes in staffing levels and judges' grades, but when examining the characteristics of the establishment of environmental tribunals, none of them is a program that responds to the reality of environmental protection.

The principle of uniformity requires not only uniformity of judges, but also uniformity of the law, and the realization of the former goal requires that the appointment of judges should be selected through a transparent, open and competitive process. The latter goal requires that the law be relatively stable and not subject to change. The power to interpret the law, as well as judicial interpretation, is the basis of the Supreme Court's authority and an important institutional tool for removing barriers to rule-based reforms led by the Supreme Court itself. The principle of legality is realized on the basis of the uniformity of the law, and at the same time promotes the realization of the uniformity of the law. The prerequisite for the exercise of subjective initiative by judges is compliance with the law, and, based on the capacity of grass-roots courts to administer environmental justice and with reference to the fact that courts in different countries have set up environmental tribunals at higher levels of the international hierarchy, the setting up of environmental tribunals in the supreme, high and intermediate courts is in line with the provisions of the law as well as with the capacity of the judges to adjudicate environmental cases.

4.3.2. Staffing of expert trial teams. “How well a system functions must depend on the quality of those who operate it.” China's court system does not have a specialized trial team for the judicial protection of environmental resources, which has become a major factor restricting the long-term development of environmental justice specialization. With the increasing strength of environmental resources protection, environmental public interest litigation will frequently come into the public eye, the formation of specialized trial team, training has been put on the agenda.

Judging from the types of cases received by courts at all levels, civil cases account for the largest proportion, so priority should be given to selecting and training judges engaged in environmental resources trials from among those who are well versed in the law, have extensive experience in civil trials, and, in particular, have an academic background in science and technology. When encountering criminal and administrative cases involving environmental protection disputes, criminal and administrative trial judges should be temporarily absorbed to participate and jointly form a collegial court to hear the cases, so as to complement each other's strengths and unify our understanding. As the trial of environmental protection cases matures, the criminal and administrative trial judges will be enriched to expand this specialized trial team. At the same time, there should be a plan to arrange training to realize the elitism of the environmental protection trial team, and to cultivate a group of composite judges with knowledge of both environmental law and environmental science.

5. Conclusion

Environmental legal dispute resolution mainly utilizes consultation and litigation in the ecological environmental damage compensation system, but it is difficult to meet the needs of environmental damage compensation cases by relying on these two dispute resolution mechanisms. In this paper, environmental legal dispute resolution is regarded as a multi-objective decision-making optimization problem, and an improved multi-objective particle swarm algorithm is introduced to solve the optimal solution, exploring the legal applicability of environmental legal dispute resolution and the optimization path. By applying the improved multi-objective particle swarm algorithm to the multi-objective decision-making optimization model of environmental legal disputes, the time to find the optimal solution is as low as 2.314 s. Based on the consideration of the number of environmental legal provisions, the implementation time of environmental laws and the number of subjects involved in mediation of the disputes, the objective function values obtained by this paper's algorithm are 1.67, 4.54, and 4.81 times higher than those obtained by considering only the number of environmental legal provisions. 4.81 times. Therefore, environmental legal disputes need to focus on considering the number of environmental law provisions, the implementation time of environmental law and the number of subjects involved in dispute mediation, and need to introduce punitive damages and connect administrative law with criminal law, so as to get the optimal solution for environmental legal dispute resolution.

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