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Numerical assessment of the environmental impacts and carrying capacity of deep sea cage culture in the Yellow Sea

Yunxia Zhao, Jihong Zhang
Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences, Qingdao 266071, PR China

1. Introduction

In light of environmental deterioration in coastal areas, deep sea cage aquaculture is becoming an increasingly attractive mode of mariculture. A key factor in determining the potential of deep sea cage aquaculture is to evaluate the environmental impacts of these practices. Based on the environment assessment, the guidance of the environmental carrying capacity is urgently needed.

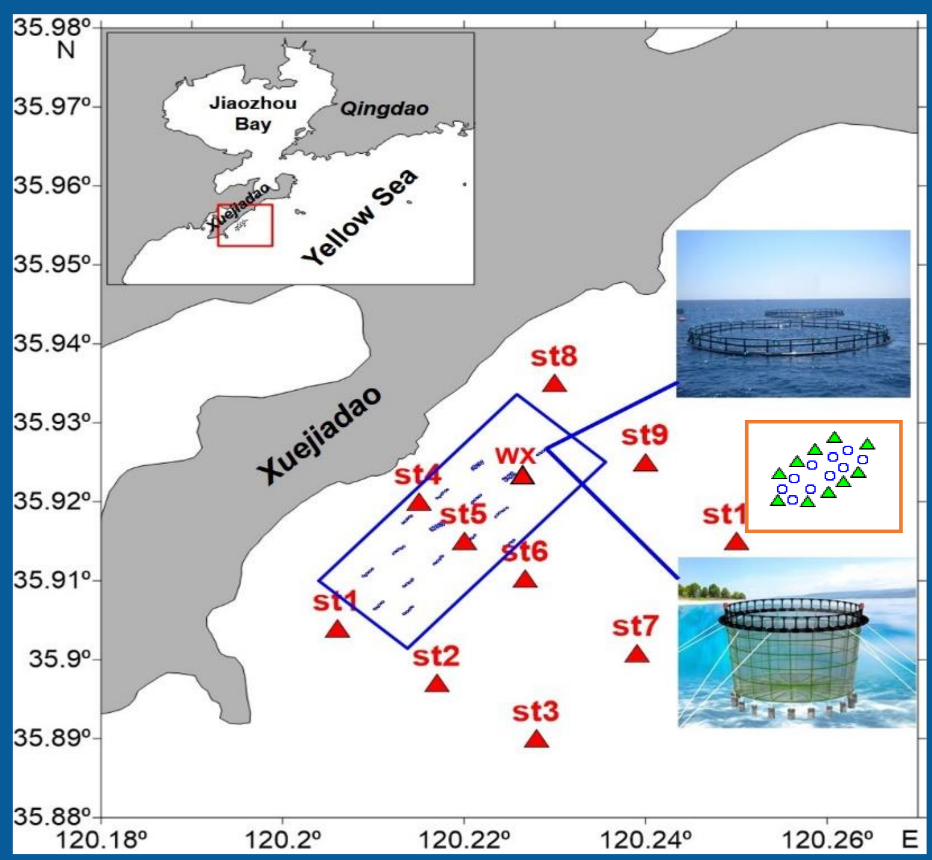

Fig. 1. Research site of the deep sea cage culture area located offshore area of Qingdao, in the Yellow Sea. Red triangles are the sampling stations and blue points are the deep sea cages' positions during the field observations.

2. Methods

A numerical model consisting of coupled hydrodynamic-, tracer-tracking- and 3-D Lagrangian particle-tracking models was set up and applied to evaluate the environmental impacts of deep sea cage cultivation of sea bass (*Lateolabrax japonicus*) in the Yellow Sea, China (Fig. 1). The model was verified using water level data on August 1–31, 2018 and nutrient concentration in water and surface sediments in May, August, and November, 2018, and January, 2019 (Fig. 2).

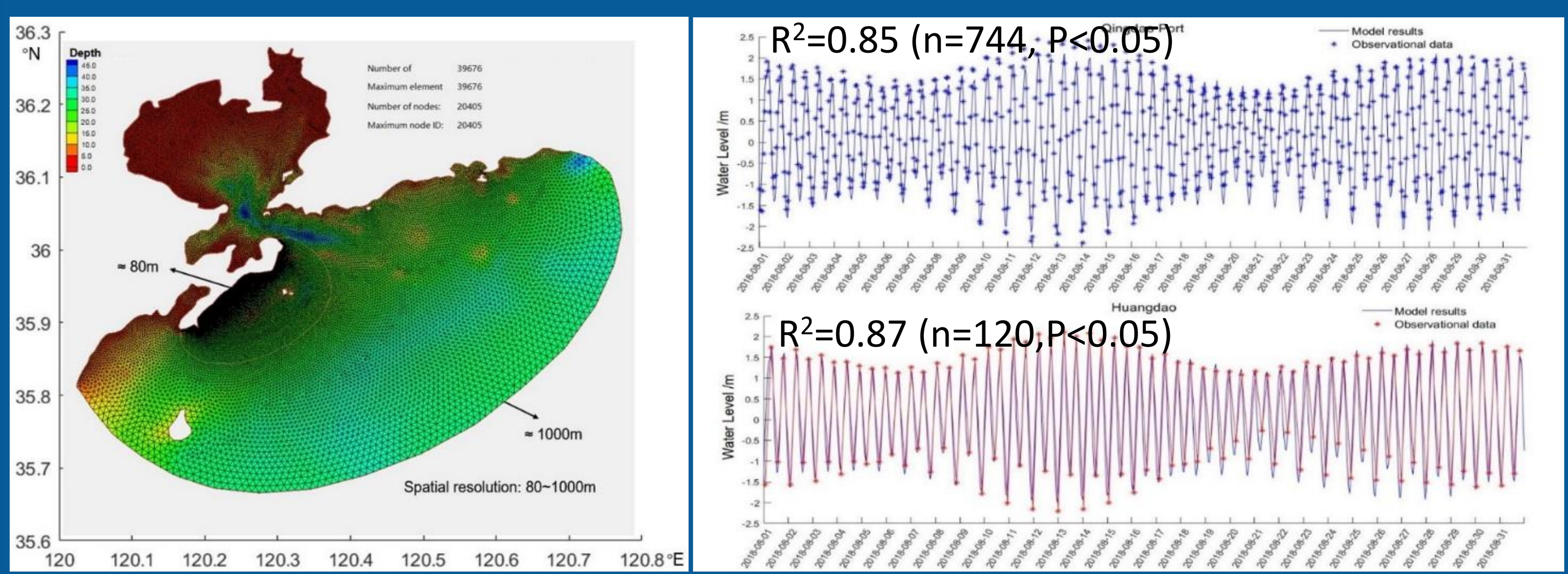

Fig. 2. FVCOM's triangular computational grid superimposed with a topographic map of the study area (left). Comparison of water level observation data and simulation results in Qingdao port and Huangdao Port in August 2018 (right).

3. Results and discussion

The model was verified using water level data on August 1–31, 2018 and nutrient concentration in water and surface sediments in May, August, and November, 2018, and January, 2019. Results show that the model successfully captures the characteristics of local tidal currents and the total particulate nitrogen and phosphorus concentrations of the underlying sediments. Water quality simulations indicate that deep sea cages account for 26% of the total dissolved inorganic nitrogen and 19% of the active phosphorus content(Fig. 3). The superposition particles (residual feed particles and feces) were predicted to settle in an ellipse with a long axis of 320 m and a short axis of 150 m(Fig. 4).

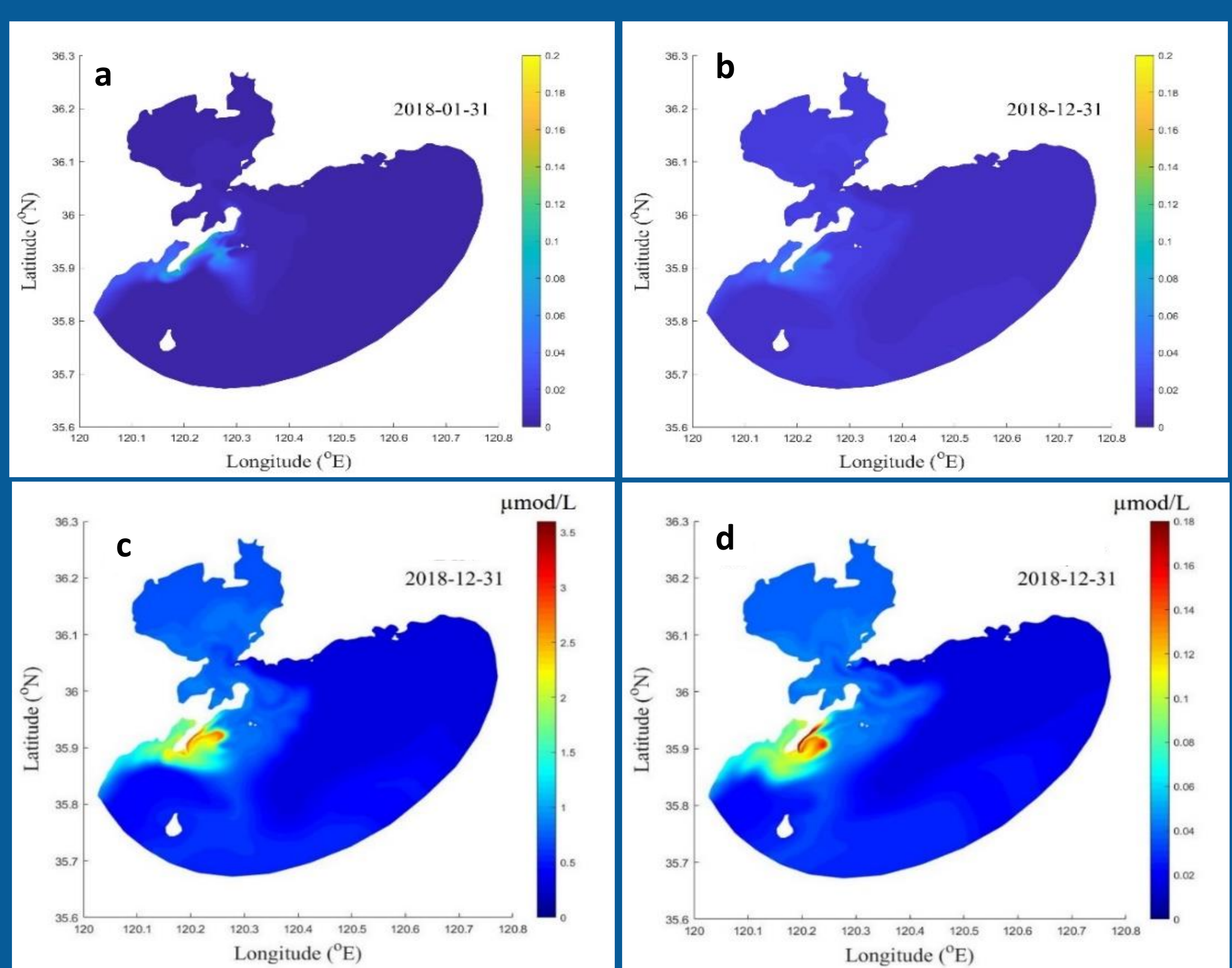

Fig.3. Diffusive distribution of DIN (a) and PO_4^{3-}-P (b) concentrations (μmod/L) in the surface layer simulated by the tracer-tracking. Predicted distribution of DIN (c) and PO_4^{3-}-P (d) generated by active use of all installed cages (simulating with three times the present culture density).

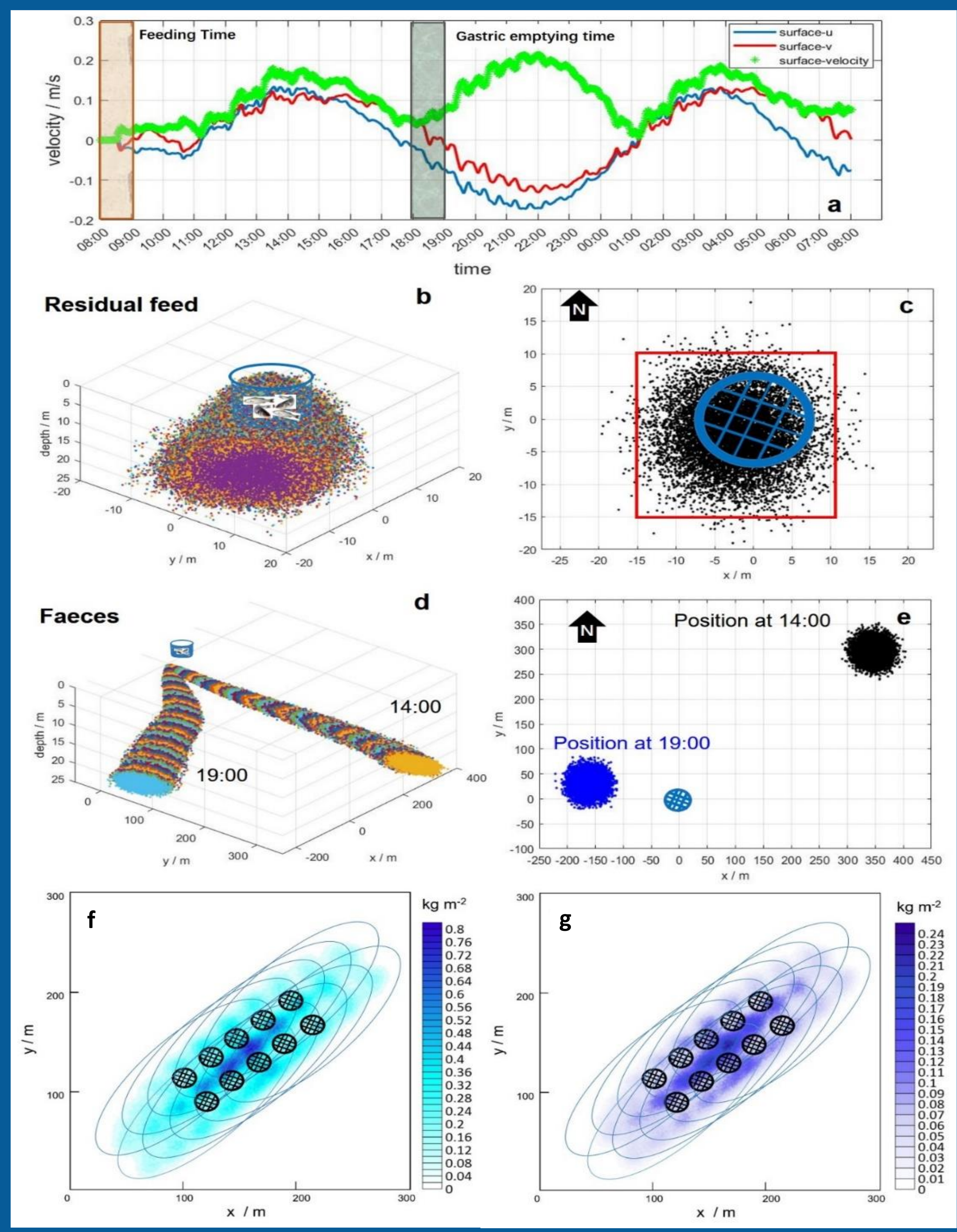

Fig. 4. Deposition process of residual feed and faeces after feeding at 08:00 am on August 1, 2018. (a) Surface velocity components u (red line), v (blue line) and velocity value (green stars); (b) 3-D diagram of residual feed particles settlement; (c) Bottom deposition range of residual feed particles; (d) 3-D diagram of faeces particles settlement; (e) Bottom deposition range of faeces particles. The blue circle containing a net in Fig. 4b-e represents the real cage at scale. The scattered points with different colors in Fig. 4b, d represents the deposition positions of particles at different water layers; predicted deposition density of TN (f) and TP (g) generated by a group of cages (simulating with three times the present culture density).

4. Conclusions

The model results indicate that installation of all deep sea cages will lead to acceptable levels of water quality, but that sediments may become polluted. According to the acceptable standards of sediment nitrogenous nutrient (TN), the sea bass culture density can be expanded to 1.46 times the present level to reach the environmental carrying capacity(Fig. 5).

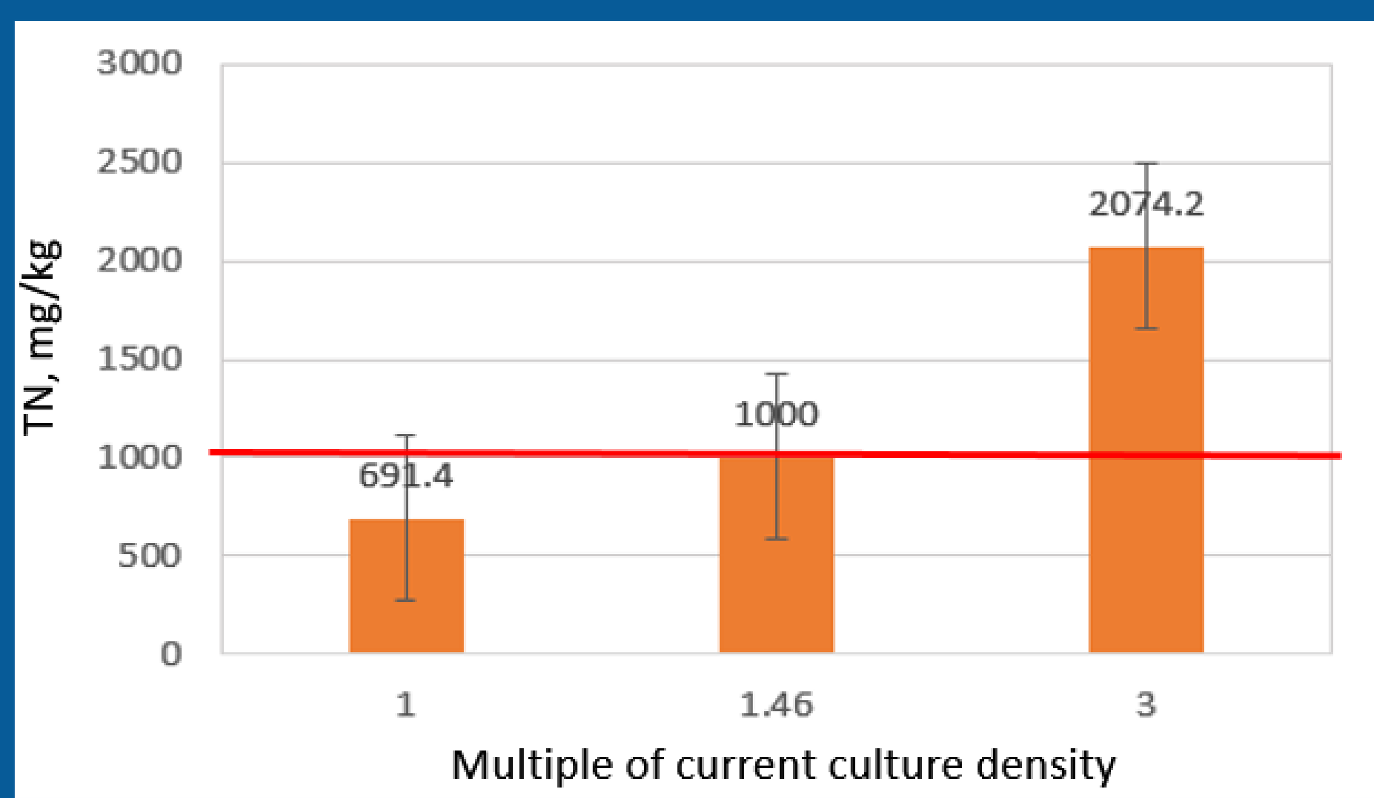

Fig.5 Environmental carrying capacity under the limitation of TN

The accumulation of particulate matter is a cumulative process, and most of the particles are deposited around the fish farm. Therefore, farmers should conduct intensive monitoring of local sediments. Another side, feed formulations and feeding regimes are important factors in determining the carrying capacity that need to be strategically improved with developing technology. Our model provides an effective method to predict the environmental impacts of deep sea cage aquaculture, which can support the development of relevant policies and strategies for sustainable development.

References:
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