

## Text S1: Illustration on the transition process curves of urban–rural construction land and population

The improved transition process theory of urban–rural construction land (URCL) and population proposed in the paper is a conceptual model. The theory is derived based on the logistic population urbanization model and the ideal per-capita construction land area (PCL) of urban construction land (UCL) and rural construction land (RCL). The derivation process and related formulas are as follows:

### (1) formulas for population:

$$\begin{aligned}URP &= UP + RP \\UP &= URP \times PUR \\RP &= URP \times (1 - PUR) \\PUR &= \frac{PUR_E}{1 + (PUR_E/PUR_S - 1)e^{-k(t-t_S)}}\end{aligned}$$

### (2) formulas for URCL:

$$\begin{aligned}URCL_{is} &= UCL + RCL_{is} \\URCL_{as} &= UCL + RCL_{as} \\UCL &= PCL_{u_{rv}} \times UP = PCL_{u_{rv}} \times URP \times PUR \\RCL_{is} &= PCL_{r_{rv}} \times RP = PCL_{r_{rv}} \times URP \times (1 - PUR) \\RCL_{as} &= PCL_{r_{rv}} \times URP \times (1 - PUR) + PCL_{r_{rv}} \times URP \times APR \\LUR_{is} &= \frac{UCL}{URCL_{is}} = \frac{UCL}{UCL + RCL_{is}} = \frac{PCL_{u_{rv}} \times URP \times PUR}{PCL_{u_{rv}} \times URP \times PUR + PCL_{r_{rv}} \times URP \times (1 - PUR)} = \frac{1}{1 + \frac{PCL_{r_{rv}}}{PCL_{u_{rv}}}(\frac{1}{PUR} - 1)} \\LUR_{as} &= \frac{UCL}{URCL_{as}} = \frac{UCL}{UCL + RCL_{as}} = \frac{PCL_{u_{rv}} \times URP \times PUR}{PCL_{u_{rv}} \times URP \times PUR + PCL_{r_{rv}} \times URP \times (1 - PUR) + PCL_{r_{rv}} \times URP \times APR} = \frac{1}{1 + \frac{PCL_{r_{rv}}}{PCL_{u_{rv}}}(\frac{1 + APR}{PUR} - 1)}\end{aligned}$$

### (3) formulas for the PCL of URCL:

$$\begin{aligned}PCL_{ur_{is}} &= \frac{URCL_{is}}{URP} = \frac{UCL + RCL_{is}}{URP} = \frac{PCL_{u_{rv}} \times URP \times PUR + PCL_{r_{rv}} \times URP \times (1 - PUR)}{URP} = PCL_{u_{rv}} \times PUR + PCL_{r_{rv}} \times (1 - PUR) \\PCL_{ur_{as}} &= \frac{URCL_{as}}{URP} = \frac{UCL + RCL_{as}}{URP} = \frac{PCL_{u_{rv}} \times URP \times PUR + PCL_{r_{rv}} \times URP \times (1 - PUR) + PCL_{r_{rv}} \times URP \times APR}{URP} = PCL_{u_{rv}} \times PUR + PCL_{r_{rv}} \times (1 - PUR + APR)\end{aligned}$$

**(4) The definitions of variables in the above formulas are as follows:**

- $URP$ : urban–rural population size;
- $UP$ : urban population size;
- $RP$ : rural population size;
- $PUR$ : population urbanization rate;
- $PUR_E$  and  $PUR_S$ : ending and starting point of PUR separately;
- $k$ : growth coefficient of PUR;
- $t$ : time point in the process of Urbanization;
- $t_s$ : time point at the starting point of PUR;
- $URCL_{is}$  and  $URCL_{as}$ : urban–rural construction land area in ideal and actual situations separately;
- $UCL$ : urban construction land area;
- $RCL_{is}$  and  $RCL_{as}$ : rural construction land area in ideal and actual situations separately;
- $PCL_{u_{rv}}$  and  $PCL_{r_{rv}}$ : ideal per-capita construction land area of UCL and RCL separately;
- $APR$ : amphibious population rate (the proportion of the population who are urban residents but still occupy residential land in rural to URP);
- $LUR_{is}$  and  $LUR_{as}$ : land urbanization rate in ideal and actual situations separately;
- $PCL_{ur_{is}}$  and  $PCL_{ur_{as}}$ : per-capita construction land area of URCL in ideal and actual situations separately.