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Chinese Cities: Renewal of the Dense Residential Areas, The Financial Feasibility and Strategic Choices for a Sustainable Future

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***Abstract*:** *Redevelopment or urban renewal of the residential building stock in Chinese cities will bring large challenges the coming decades. The high density of the building stock and the high floor area ratios used the past decades and nowadays still being used result in an unsustainable living environment. This not only influences the lifespan of the building stock, it also influences the social satisfaction and will bring more and more pressure on the governmental budgets, ultimately resulting in negative consequences for the users at the end of the line. In this research, a material flow analysis is used to estimate future residential redevelopment volumes in Chongqing's Yuzhong district till 2040, the annual costs of redevelopment are estimated using a breakdown of gross project cost, the new program size to break even the redevelopment cost is calculated and strategic choices to grow to a more sustainable future introduced. For every square meter demolished floor space, approx. four has to be rebuild to cover the cost of urban renewal. In Yuzhong district there's no new development space left in a few years. The already high floor area ratios of the redevelopment areas make it impossible to cover the future cost of urban renewal on the same location. The main reason of redevelopment is not because the quality of the building stock, but for city planning. Adequate vision making and master planning can prevent preliminary redevelopment, extend the lifespan of buildings, hereby decrease the urban renewal budgets and increase the social satisfaction, results are long-term. Short-term measures the government can take to decrease the deficits are raising the land quote, land speculation and finding resources elsewhere, like compensation projects outside Yuzhong district.*

Keywords: *urban renewal, lifespan, material flow analysis, residential redevelopment.*

1. Introduction

The past decades China has been developing very fast and the Chinese economy might be slowing down but is still growing at a fast pace. The construction boom started in the 90s is still going and more than half of the urban residential and commercial building stock is constructed after the year 2000. To generate more income from land sales, governments use different strategies, resulting in dense residential areas and business districts. The most common used strategy is increasing the Floor Area Ratio (FAR) [1,2,3]. This strategy is used all over the world, to generate income and to cover the costs of urban renewal [4,5]. From city planning, economic and environmental perspective, intensive land use is highly recommended, as land is a scarce product. Only the balance between these perspectives in Chinese cities is missing.

The lifespan of buildings in China is often topic of conversation. Most residential buildings are constructed to technically last 50 years, this according to the quality standards [6]. In the past decade, there have been several studies about the lifespan of residential stock in Chinese cities. Result from these studies all show an average lifespan of approximately 30 years [7,8,9,10,11] and the living environment of these dense areas might experience problems even earlier. Several studies have identified factors of urban renewal [7,12,13,14,15,16,]. Most of the factors in these studies are external. The main reason for the short lifespan of residential buildings in

Chinese cities is city development (78%). Only 12 percent of the buildings is demolished because of quality reasons and the resting 10 percent because of changing needs [8].

Redevelopment or urban renewal of the residential building stock in Chinese cities will bring large challenges the coming decades. The high floor area ratios used the past decades and nowadays still being used result in an unsustainable living environment [2]. Projects are profit driven [2,17,18], government employees are examined on economic results [1] and architects have no choice, they're at the end of the line [3]. This not only influences the lifespan of the building stock, it also influences to social satisfaction [12] and will bring more and more pressure on the governmental budgets, ultimately resulting in negative consequences for the users at the end of the line. Combining the extreme dense residential areas with the short lifespan of the stock the financial burden of redevelopment seems enormous.

Several studies have been made to the use of high floor area ratios in China and in the field of redevelopment, but no studies can be found about urban renewal of dense urban areas other than some studies mentioning a few words. Studies usually focus on the past and present situation. The costs of urban renewal are also not frequently being researched most studies are resulting from the post WWII period [19,20]. Studies about the lifespan of Chinese real estate are commonly found, but don't focus on the cost aspect. No studies have been found estimating future redevelopment volumes on a city or district scale. While this approach is particularly interesting for strategy and policy making. Studies on (re)development strategies look back and focus on current used strategies, no suggestions for future improvement are done. This survey will give an insight of the future redevelopment volumes and cost of urban renewal in Chinese cities by taking Yuzhong district, the centre of Chongqing as a case study. Yuzhong district is the densest area of Chongqing and one of the densest areas of China [21] and because the natural elements of a mountainous area with two large rivers as natural borders make land use planning even more challenging. The area of Yuzhong district is 18.54 km^2 of dry land and 23.71 km^2 including parts of the rivers. In some sub-districts the density of the population is higher than 100.000 people a square kilometre [22].

A material flow analysis is used to estimate future residential redevelopment volumes in Chongqing's Yuzhong district till 2040, the annual costs of redevelopment are estimated, the new program size to break even the redevelopment cost calculated and strategic choices to grow to a more sustainable future described. The results of this study can serve as input for the discussion about the future living environment in Chinese cities.

2. Research Methodology

The method of using stock and changes to the stock to estimate the lifespan and the future outflow of a certain product is being used in marketing to forecast the replacement market. In accounting, it's used for depreciation and analysis. And outflow data on lifespan is used as input for waste management. The method is being used for various products, from electronic equipment as cell phones, computers, refrigerators till cars and buildings [23]. For example, for buildings the future amounts of demolished concrete are estimated, as this is being recycled as foundation for new roads. The method used is called a material flow analysis (MFA) or material stock analysis. The lifespan varies from product till product and market. To estimate the outflow distribution, methods in research areas as reliability engineering and demography have been established. The model to estimate outflow, in this case demolition of a building, is called a delay model [24]

$$\text{outflow}(t) = \text{inflow}(t - L)$$

The outflow in a certain year is equal or a function of the inflow in the past. In demographic research this method is equal to estimating the population rate, inflow are births and outflow are deaths. Stock is estimated by observing the in- and outflows in certain periods also called time series. More information or a longer time series will result in a more accurate estimation. For the lifespan of buildings, Komatsu [25] and Mueller [26] used time series data to estimate the outflow in a certain year.

Products or in this study the residential floor space completed in a certain year (inflow) follow a certain distribution till outflow. In past research, several statistical distributions have been used to estimate lifespan of

buildings and other durable goods. Common used distribution functions to estimate future outflows are the normal distribution, logarithmic (log)normal distribution and Weibull distribution.

Kato [27] and Komatsu [25] applied the lognormal distribution for estimation of the lifespan of wooden houses. Choi [28] applied four different distributions to estimate the lifespan of buildings through statistic research. The Normal distribution, Gamma distribution, Weibull distribution and the Log normal distribution and concluded that the lifespan of buildings approximates that of the Normal distribution and the Weibull distribution. Yashiro [29] used the Normal distribution, log normal distribution and Weibull distribution to estimate the lifespan of steel and concrete office buildings. Hashimoto [30], applied the Weibull and Log Normal distribution to estimate lifespan of several types of buildings, dwellings and offices made from steel, concrete, wood. Mueller [26], used the Normal distribution, log normal distribution and the Weibull distribution in his analysis to estimate the lifespan of buildings and other commodities. Mueller [31] used a normal distribution to estimate future amounts of demolished concrete in the Netherlands. As there is not one distribution proven to be the most accurate in estimating the lifespan of buildings, in this study the normal distribution is used.

3. Results

The accuracy of estimations relies on the input data, the longer the period the higher the accuracy. The figures about the residential building stock till 2015 serve as input for estimation of the completed floor space till 2030. Historical data about the building stock from before 1950 till 2015 are for a substantial part available. This period is longer than the average lifespan of a building and even exceeds the norm of 50 years, which most of the residential buildings technically are constructed for. Stock data from before 1986 is well documented per decade of construction and function [32]. From the period 1986 – 2015 no figures were published about the total residential stock nor the total building stock. Figures that are published in the statistical yearbooks [33] are the annual floor space completed in Chongqing (1986-2014) and for Yuzhong district the annual floor space and annual residential floor space completed (2003-2014). From this data, the missing years are calculated using an average grow. Fig. 1 shows an exponential increase of floor space completed over the past thirty years. The total amount of completed floor space in the period 1985-2000 is less than completed in the year 2012 (the highest peak).

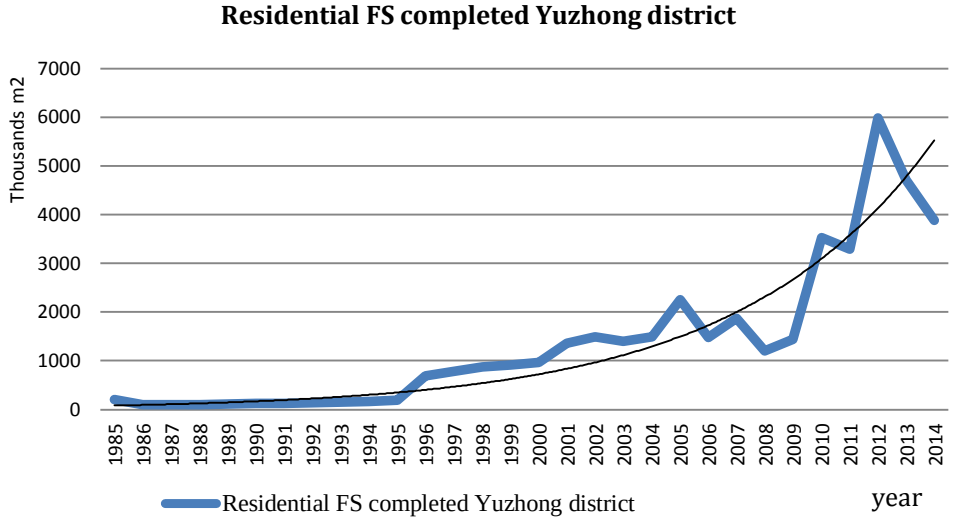

Fig. 1: Floor space completed Yuzhong district 1985 - 2014

To make an estimation of the future amount of floor space being demolished till the year 2040 the residential floor space completed for the period 2015 -2030 is estimated. To eliminate the assumption risk three scenarios are used. (Fig. 2):

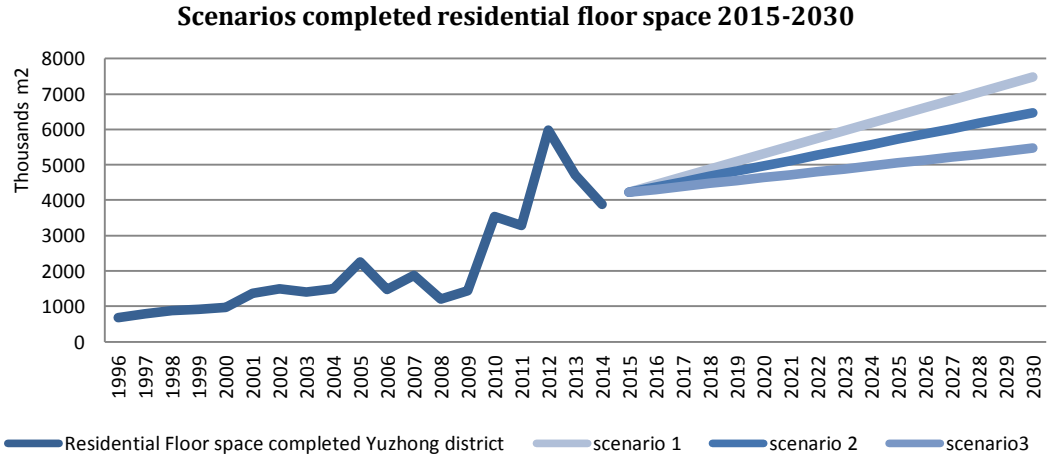

Fig. 2: Future scenarios residential floor space completed Yuzhong district till 2030

Scenario 1 (maximum), annual increase ca. 210.000 m2 (following the linear trend line from 1996 – 2014)

Scenario 2: (most likely), annual increase ca. 150.000 m2 (following the linear trend line from 1985 – 2014)

Scenario 3: (minimum), annual increase of ca. 80.000 m2 (predicting a slowdown in the market)

There's is no negative scenario because this seems almost impossible looking at the amounts of floor space under construction in 2014 being more than six times higher as completed over the year 2014 [33]. A more positive scenario might be possible in economic high tide, but as regulations for financing real estate projects got stricter and land is a scarce product in Yuzhong district, the trend is otherwise.

For the period 2015-2040 the annual residential floor space demolished is estimated using a material flow analysis following the normal distribution, with a mean of 30 years and a maximum lifespan of 50 years where 97.5 percent of the stock has been demolished after 50 years (95% certainty level). The historical figures that served as input for the estimations date back far enough for a complete lifecycle, because of this the variation between the outcome of the calculation and statistical figures should not be too large. The average outflow figures from the last 5 years (2011-2015) [34] compared to the calculated figures show an average outflow of respectively 189,780 and 206,591 square meter residential floor space. The amounts of demolished residential floor space follow the normal distribution very close. The calculated outcome is 99.1 percent of the statistical figures. We can conclude that the residential floor space follows a normal distribution from inflow (floor space completed) into the market till outflow (demolishment). Using the normal distribution to estimate the amount of residential floor space being demolished in a certain year is hereby proven to be accurate.

The calculated annual outflow figures till 2040 for the three scenarios show a very small variation. This due to the first years after completion (inflow) there's almost no outflow. In 2040, the difference between scenario one and three is 178,000 square meters. This amount of floor space is equal to one residential block with six till eight residential buildings of approx. thirty floors. Because the minimal variation scenario two is used in the next part of the research.

For every single year of inflow (1965-2014) an outflow distribution is calculated. A chart with 50 different lines is unreadable so in Fig. 3 the future amounts of residential floor space being demolished till 2040 are divided into four parts. The past 30 years the residential floor space completed in Yuzhong district saw an exponential grow with a top in 2012. After a minor slowdown, the amounts of floor space under construction show the building boom is still continuing. According to the average lifespan of 30 years, a large part of the building stock completed in the 90s will be redeveloped the coming decade. The quality of the construction itself

might still be fine, but the major reason for redevelopment is city planning (78%) [8]. In the year 2020, the outflow or residential floor space demolished is 0.4 million m2; in 2025, 0.74 million m2; in 2030, 1.27 million m2 and in 2040, 2.8 million square meter. This might be the start of the redevelopment or demolition boom. From the demolished floor space in 2040 is about half build after 2014.

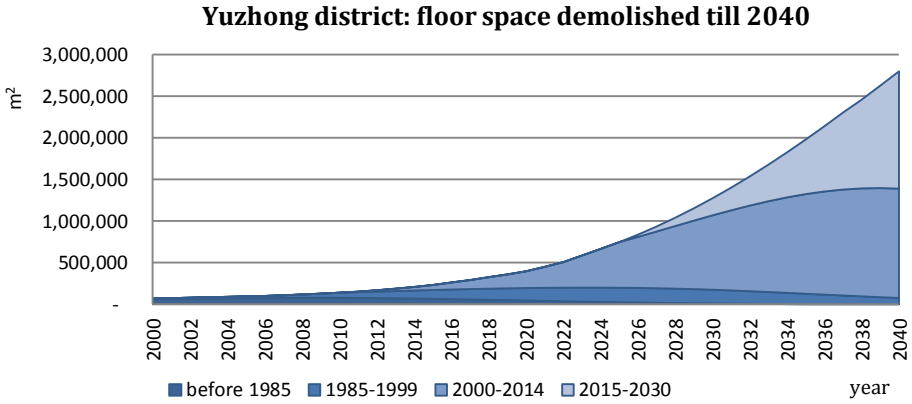

Fig. 3: Annual outflow residential floor space till 2040

3.1. Development Costs

The calculated figures about the residential floor space for redevelopment till 2040 can serve as input for various studies. In this article, the land development cost and rebuild factor to break even the development cost are estimated using a breakdown structure of gross project cost [19]. The model is modified to the nowadays common used cost groups Acquisition, site clearance, planning & project management, financing, site improvement, and other related cost. First the effect of different FAR on the breakdown structure of gross project cost is tested.

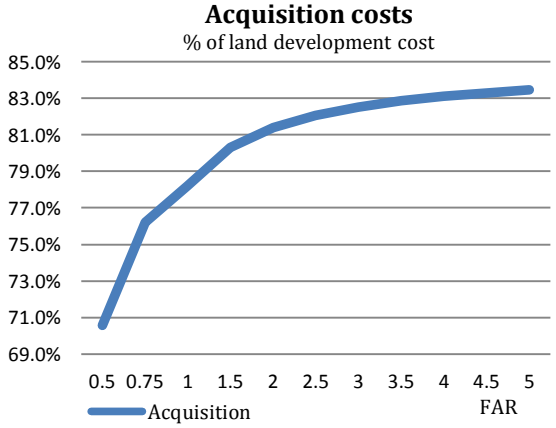

Fig. 4: Acquisition costs as part of the land development budget

Fig. 4 shows, the largest part of the land developments costs are the acquisition costs. Increasing from 70.6 percent with an FAR of 0.5 till 83.5 percent in areas with an FAR of 5. The variance in acquisition cost from FAR 1.5 till 5 is only three percent. When the FAR increases the acquisition cost, site clearance cost, project management cost and financing cost increase too. The cost for site improvement and other related costs like contingency reserves (common use is percentage of site improvement costs) are not related to the FAR and don't change. The advantage of using a cost break down is, when one cost group is known the others can easily be calculated. This is a useful method in a market with many similar projects, as in the Chinese market, most residential areas are based on the same principles. It is clear that the acquisition costs count for the largest part of the development cost. The annual outflow or floor space demolished and the acquisition costs use the same unit, gross floors area (GFA). The annual acquisition and land development cost can easily be calculated.

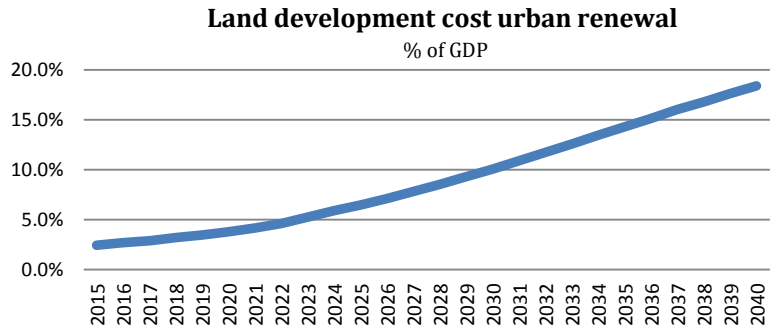

Fig. 5: Land development cost as a part of GDP Yuzhong district.

The land development costs have always been a minor part of the GDP. But as the residential stock for urban renewal grows the investment sum grows with it. Fig. 5 shows the land development cost for urban renewal as a part of the GDP of Yuzhong district. In 2020, the costs of urban renewal or redevelopment of the residential stock are less than four percent of the GDP; in 2030, 10.1 percent and this grows till 18.4 percent in 2040. (In the calculation a FAR of 3.5, price index of 6% and a GDP grow rate of 8% are used).

The land price for new developments in Chongqing is calculated using a land quote method. The mayor of Chongqing said the land quotes must not exceed 35% and the common used land quote is 1/3 of the housing price [35]. To calculate the rebuild factor to break even the cost of redevelopment of residential areas using current strategies the following formulas are used:

Land development cost = housing price / % acquisition cost as part of land development cost

Rebuild factor = Land development cost / (housing price x land quote)

(Land development cost and housing price in RMB per square meter GFA)

For Yuzhong district this results in a rebuild factor of 3.5 till just above 4 using a land quote of respectively 35 percent and 30 percent.

4. Strategy / Conclusion

First the annual outflow (redevelopment volume) for Yuzhong district was calculated and second the rebuild factor to break even the development cost. Combining those two, gives an insight about the size of the new development program to break even the cost of urban renewal. As the most common used development strategy is, increasing the floor area ratio to compensate the costs. This strategy has been used the past decades and is still being used today. The largest part of the building stock redeveloped the past decades were low and mid-rise buildings till max. 7-8 floors high. Realising a rebuild factor of 4 results in new developments from 28 till 32 floors high. Nowadays new developments from these dimensions can be seen everywhere in Chinese cities. In many of these realized projects the sustainability of the living environment can be questioned. Yang [2] writes current redevelopment projects are worsening the environmental living conditions. Chen [17] concludes the results of redevelopment as an imbalance between results and profits, the density too high and living conditions not improved. The last ten years there have been no or minor changes to this process, the FAR and with that profit maximisation are still leading. However, there is a major changing factor coming. The residential building stock "ready" for redevelopment the coming decades is mostly 7 floors and higher. For buildings higher than eight floors, the current strategy is hard to use. Technically the construction of residential buildings higher than 100 meter (ca. 33 floors) brings no problems, other than slightly higher construction costs, but the living environment in projects realized with extreme high FAR is not be sustainable. Besides that, the capacity of the public infrastructure has to be upgraded, usually resulting in less land for development. As long as the city keeps expanding, revenues from new projects can compensate urban renewal costs. In Yuzhong district land is a scarce product and there's no area for new development left in a few years. The urbanisation already had devastating effects on its green space [22].

Within the borders of Yuzhong district the future cost of urban renewal cannot be covered by rising the floor area ratios, nor by new developments because there is simply no space. Leaving the current development strategy behind, solutions elsewhere have to be found. The government is the major stakeholder in the city planning and land development process, this makes it easier and faster to take measures than in a market with many stakeholders. The main reason of redevelopment is not because the quality of the building stock or user satisfaction, but for city planning. Improvement at the front of the chain will have positive effects at the end. Adequate vision making and master planning will prevent preliminary redevelopment, extend the lifespan of buildings, hereby decrease the urban renewal budgets and increase the social satisfaction. Effects of these measures are long term, as the average lifespan of a residential building nowadays is about 30 years.

Governments often choose short-term profits instead of measures for a long-term sustainable living environment. Short-term administrative measures the government can take to decrease the deficit are. Raising the land quote, this will result in more revenues from land sales but will also result in increasing housing prices. A second option is land speculation, with the increasing housing prices, early acquisition and late sales might be profitable, if internal interest rates are lower than the housing price index. A last option is compensation projects outside Yuzhong district, in new areas as Chayuan district, this requires corporation of different district governments and might bring internal challenges with the transfer of revenues from one district to another.

This is the first study that quantified the future residential redevelopment volumes and cost, as a result of the unsustainable way of residential development from the past decades till now. The results of this study may serve as input for economists, policy makers and other specialists to come to a more sustainable city development model.

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