COMMON VALUE: TRANSFERRING DEVELOPMENT RIGHTS IN THE FACE OF CLIMATE CHANGE CHALLENGES

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Abstract: Flooding accounted for more than 37% of natural disasters in 2017, affecting 55 million people and amounting to 20.3 billion $ of economic losses worldwide. These figures are the highest in the last decade and with higher urbanization rates, the number of people living in precarious and flooding prone areas is increasing. Under the light of these challenges, Flood Risk Management narrative is evolving towards integration of nature-based solutions and Green Infrastructure. This paper investigates the role of Land Value Capture instruments in financing Green Infrastructure. More specifically, this research focuses on the Transfer of Development Rights (TDR) instrument, which has enabled some planning authorities in the global north and south to successfully adopt preventive measures in flooding prone areas. Through TDR, property devaluation in flood prone areas or areas where Green Infrastructure is to be implemented is cross-subsidized through capturing part of the "windfalls" in properties benefiting from GI, by transferring development rights from the former to the latter.

Keywords: Flood Risk Management, Green Infrastructure, Land Value Capture, Transfer of Development Rights

Introduction

Floodplains can be described as areas between levees or within the river valley, which can be inundated or overflowed when the river becomes "too full" (Hartmann, T., 2016; Cambridge University Press, 2019). Yet floodplains are also the locations where the first civilizations emerged. The ever going symbiotic yet conflictual relationship between water and human activity is not a contemporary phenomenon; indeed Hartmann (2016) refers to floodplains as contested land. However, with the latest trends of urbanization and increased occurrence of extreme weather events and flooding possibility, the amount of human resources and capital exposed to flood risk is increasing.

There is now a common accordance that higher levies and grey protective infrastructure alone will not resolve the future flood protection needs; perversely it might contribute to higher vulnerability towards disasters from unpredicted and extreme weather events. For instance, traditional solutions to flood, like levees take up space from the river beds, reducing their retention capacity and therefore contributing to higher exposure to flood risk over time. Hartman (2016) illustrates this phenomenon with a specific example, referring to River Elbe that lost 2,300,000,000 m3 of its retention volume since the 12th century, which for a specific locality, such as Wittenberge can translate into an increase in water levels by 50cm. Therefore, flood risk management narrative is shifting more towards finding nature-based solutions and investing in green infrastructure (GI). However, there are various barriers that hinder the implementation of green infrastructure, the most relevant of which have to do with development pressures in flood prone areas, scarcity of land for accommodation of GI and lack of financial resources for their implementation (O'Donnell *et al.*, 2017).

On the other hand, various studies have revealed the impact that GI has on land markets (Lamond and Proverbs, 2006; Bin and Polasky, 2013; D'Acci, 2018; Jung and Yoon, 2018; Zhang *et al*., 2018). Recouping some of the incremented value of land by the public authority, with the purpose of covering all or some of the costs of providing infrastructure and services is what is usually referred to as Land Value Capture. Smolka and Amborksi (2000) define LVC as "the process by which a portion of or all land value increments attributed to the 'community effort' are recouped by the public sector either through their conversion into public revenues through taxes, fees, exactions and other fiscal means, or more directly in on-site land improvements for the benefit of the community". LVC has been widely investigated as a means to finance infrastructure and promote sustainable urban development, however not much literature is available about its role in Flood Risk Management programs – most research is related to transport infrastructure and traditional methods of tax capture and/or betterment. The purpose of this paper is to explore the potential how LVC can facilitate the implementation of GI, by focusing on one particular LVC instrument: Transfer of Development Rights.

Flood Risk Management and Green Infrastructure

A recognition for more sustainable and natural solutions has increasingly become a cross cutting topic in various international, national and local FRM policy documents. The 2007 Flood Directive of the European Union for instance, points towards the need of providing more space for rivers as a sustainable flood prevention measure. The European Commission Strategy ''Green Infrastructure (GI) - Enhancing Europe's Natural Capital'' further highlights the need for mainstreaming green solutions to urban problems, including disaster risk management. Green Infrastructure1 is defined as ''strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services'' (European Commission, 2013). Dutch authorities have recognized since 2000 that the current water management systems relying on technological solutions and grey infrastructure will be insufficient to face future coastal and river flooding risks; hence more space should be made for water. Similarly, the aftermath of Hurricane Katrina in 2005 has pressured policy makers in the state of Louisiana and the city of New Orleans to think of alternative ways to increase the urban resilience towards extreme weather events. Consequently, the New Orleans Masterplan emphasises the need for a shift from traditional flood protection infrastructure to more natural solutions, including solutions such as wetland conservation (Kazmierczak and Carter, 2010).

The integration of GI in urban areas provides many advantages in comparison to grey infrastructure, from integrating urban green with other urban infrastructures, to multifunctionality, serving not only its

[1] Here the term "Green infrastructure" is used interchangeably with "Blue Green Infrastructure"

infrastructural purpose but also an ecological, social and economic role. Due to its multifunctional properties, GI is considered to be more efficient in handling complexity in an urban setting in comparison to more traditional infrastructure (Hansen and Pauleit, 2014). The multifunctional nature of GI and other benefits associated with it such as increased public spaces, improved image of the city and overall contribution to a better quality of urban life are sometimes bigger drivers for implementation than their effect in climate change adaptation (Kazmierczak and Carter, 2010). Despite GI planning being more suited for urban areas in terms of aligning ecologic, economic and social interests, its implementation remains very limited and calls for a careful identification and evaluation of the barriers that restrict its mainstreaming.

Challenges for the implementation of Green Infrastructure in Flood Risk Management

While GI has attracted a lot of attention amongst academics as well as policy makers, publications and guidelines about it have by far outnumbered the actual practices of its implementation. Regardless of its many benefits when compared to more traditional alternatives, the implementation of GI seems to be perceived as more complex and remains stubbornly slow. Clean Water America Alliance (2011) has categorized the main barriers to GI implementation into four groups: Technical and Physical Barriers, Legal and Regulatory Barriers, Financial Barriers and Community and Institutional Barriers. Technical and Physical Barriers include lack of technical knowledge on GI and its benefits, lack of experience in its implementation, limited empirical information regarding its costs and benefits, as well as physical challenges such as availability of land. In terms of Legal and Regulatory Barriers, the most important challenges derive from lacking or conflicting local rules and from land use policy and property rights which might complicate matters. Lack of funding and perceived high costs for upfront implementation and maintenance are also amongst the most common barriers towards mainstreaming of GI. The multifunctional nature of GI calls for effective cooperation and partnerships between various stakeholders. Hence, education and capacity building of political leaders, administrators, professionals and of public in general is essential.

Similar findings were attained by a study in the city of Newcastle. The most prevalent barriers were of socio-political nature, from reluctance to support novel approaches, lack of knowledge and education on the subject, to lack of finance (O'Donnell *et al.*, 2017). Indeed, when it comes to implementing GI for flood prevention purposes, seeking to mimic pre-development hydrology, financial constraints are often linked to the spatial requirements of such projects, which generally demand more land available for their implementation than grey infrastructure. For example, traditional systems address storm water management through underground pipe networks, whereas a green solution might entail systems that allow storm water to infiltrate into the ground, which sometimes requires additional land reserved and designed for this purpose. Similarly, "making room for rivers" approach to flood prevention also calls for planning of submergible land, which can serve other alternative purposes as well, in terms of green and open spaces, but which cannot be developed and is ultimately reserved to its ecological, social and climate mitigation function. However, empirical studies that evaluate the economic benefits of GI, which would serve to inform decision making and explore alternative ways of financing GI, have been limited.

Nevertheless, Kazmierczak and Carter (2010) argue that while environmental protection and economic development are traditionally considered conflicting issues, recent local initiatives have provided examples of how the latter can support the implementation of green infrastructures. The municipality of Faenza is implementing an incentive program which allows developers to take advantage of higher FARs in exchange of providing green roofs, green walls, contributing to public green spaces and water retention systems. Similarly, South East Dorset local authorities are also deploying developer contributions to mitigate adverse effects that developments might exert on Dorset Heathlands. Berlin's Biotope Area Factor is another example listed by Kazmierczak and Carter (2010) in the realm of developer contributions for the implementation of climate change mitigation measures.

Notwithstanding various local initiatives in exploring the financial benefits of GI and ways of taking advantage of such benefits to support their implementation, financing of GI through capturing part of the value it creates in the land markets is still a rather unexplored path.

Flood risk management, Green infrastructure and Land markets

Understanding how the land and property market reacts to flood risk, flood events and mitigation measures, especially Green Infrastructure is an imperative step towards exploring innovative financing mechanisms through land value capture. While there is not a one size fits all formula in measuring such impacts, there are several attempts made in this direction, some of which have been summarized in the following sections.

Flood risk, flood events and Property market

Measuring the impact of flood risk and flood events in the real estate market is not a straightforward process, as real estate values tent to fluctuate due to many factors which can be location-specific and therefore difficult to isolate. However, there are some generalizations which can be drawn from the existing body of literature that shed some light into the relation between FRM and land markets. Although attempts to establish a link between disaster risk and real estate market has been considerable, most studies have focused on the ex-post side of the event, therefore analysing the impact of a disaster after it has happened (Jung and Yoon, 2018). Nonetheless, it can be safely assumed that the potential risk of a disaster, when recognized, should be reflected in the market prices of real estate goods – buildings and land.

Bin and Polasky (2003) concluded that a common finding of various studies during 1985-2001 was that properties in floodplains[2] are on average 4% to 12% cheaper than comparable properties outside of the floodplain. Indeed, a study they conducted about Pit County, North Carolina, that was hit by Hurricane Floyd in 1999, causing torrential rains and flooding, concluded that the market value of similar housing units inside the floodplain was 5.8% lower than outside of it. Also, they point out that the sale value

[2] Floodplains are defined as areas that would flood in a 100-year flood event

reduction is higher than the capitalized insurance premiums, suggesting that some potential flood damages might not be insurable. One reason for this could be that floods cause non-monetary losses, including items with sentimental value or the psychological and physical hassle experienced during and after the event by those affected, which is difficult to monetise. However, this was not the case before the Hurricane event, when the sale value difference between housing units inside and outside of the floodplain were lower than insurance premiums. This might indicate that homeowners and buyers are not completely aware of the flooding potential and the cost of potential damage, therefore underestimate the risk of living in the floodplain (Bin and Polasky, 2003). Hence risk awareness can play a crucial role in terms of how much this risk affects the real estate market.

Considering the dynamics of the real estate market, the time elapsed after the disaster is as crucial as location and distance from the flood risk areas. Jung and Yoon (2018) have analysed the impact in real estate market of both the proximity to flood prone areas and the time passed after the inundations in Gyeonggi Province, South Korea, from 2008 to 2013. Their study finds that within 6 months after the flood events, its impact on the properties under investigation extends up to 300m from the inundated area, with the following rate: 0-100m from the inundated area suffered an average of 11% depreciation in price, 100m-200m suffered an average of 7.4% depreciation in price and 200m-300m suffered an average of 6.3% depreciation in price. In terms of the magnitude of such effects in time, within the 300m distance from inundated area, the properties were studied for the intervals of 1 month, 1-3 months, 6-12 months and more than 12 months after the flooding and the effect on market prices was depreciation by 57.6%, 49.2%, 45.9% and 33.4% respectively. After 12 months the effect of the event on the single-family housing values was negligible (Jung and Yoon, 2018).

While the negative effect of flood risk and flood events in land markets can be considered a common sense, the magnitude of this impact, in terms of value depreciation, geographical impact and time duration of the impact varies widely from one case to the other. In broad terms, Lamond and Proverbs (2006) describe four different scenarios of how flood risk affects property values. First scenario refers to a low risk area, where a weather event might negatively affect property values for a while, but they bounce back soon after because the probability of reoccurrence is low. Second, intense weather events in disaster prone areas tent to not affect the property market substantially, since the market already reflects the risk, or because of established public compensation programs or insurance schemes. Third scenario refers to extreme weather events in areas previously considered safe have a considerable and long-lasting effect in the property market since the area is no longer considered safe. However, the effect of natural disasters in property market values is closely linked also to the government interventions measures. Hence, the fourth case presented shows that market prices decrease temporarily after a disaster and increase even higher than before if public funds are allocated to restore the area and protect it from future natural risks.

Green infrastructure and Property market

Different from the impact of floods on the property market, the impact of green infrastructure in the latter is still in the early stages of research. This is mainly due to the limited experience with the implementation of Blue Green Infrastructure and therefore limited cases for empirical investigation. Nevertheless, inquiries on which factors affect more the decision from the demand’s side and impact more property values have concluded in results that might be relevant to consider when discussing about GI.

Classic economic theories of land rent are mainly based on simplified models of cities with a monocentric structure, where ceteris paribus, the value of land and improvements decrease with increased distance from the city centre. On the other hand, contemporary urban location theory recognizes that with advancements in transport options and technologies, as well as with the decentralization of functions within the city, land markets reflect a more complex pattern and might not necessarily decrease with increased distance from CBD (Balchin *et al.*, 2000). Quality of life and quality of urban environments are becoming increasingly determining factors of property valuation or depreciation, but their translation in economic terms has been challenging (D'Acci, 2018). Quality of life has been defined and redefined with every study focusing on it, however a common denominator of such definitions remains safety. Nevertheless, when it comes to disaster risk management, the multifunctional character of green infrastructure brings to the table, besides its role in providing safer environments, also recreational and landscape advantages, contributing to higher quality of urban environments and to its consequent reflection in the real estate market.

Facing increased disaster vulnerability in fast growing urban areas, the Chinese government launched in 2014 its "policy of allowance" promoting the construction of sponge cities, seeking to support more sustainable urban development models that will increase cities' resilience and overall improve the urban environments and quality of life by mimicking natural processes. Shortly after, Wuhan city, one of the ten largest cities that suffer frequently from river and pluvial flooding, was selected as a pilot and scheduled to implement the sponge city working plan in 2 years' time. Covering only CNY 1 billion out of the total cost of CNY 15 billion through a central government grant, the city of Wuhan is lagging behind in the implementation of the project and is searching for alternative ways of financing (Zhang *et al*., 2018).

A study by Zhang *et al.* (2018) evaluates citizens' awareness and perceptions on urban flooding and sponge city, and most importantly their willingness to pay. Eventhough this study cannot measure the actual impact of such a project in the real estate market, it has a substantial contribution in understanding what the public's perception on the economic value of such interventions is and which elements of green infrastructure are the most significant ones in the public's perception. Flood risk perception is a combination of the perceived exposure to the flood risk and the perceived consequences this risk might cause (Zhang *et al*., 2018). While 16% and 23% of the 423 survey respondents claimed that they were impacted by floods respectively in their homes and workplaces, 73% of them responded they were affected due to the disruption of public transport, indicating that the impact of a flood event is usually much larger than the area physically affected by it. The majority of the respondents whose properties were exposed to flooding claimed that they suffered property blight, however half of them expected the property values to recover to their pre-flood levels if adequate flood protection measures were to be undertaken. Hence, most of the respondents were aware of the economic benefits of protective infrastructure in terms of safeguarding property values. Nevertheless, when asked about their appreciation towards the "sponge city" project, its multi-functional benefits, in terms of providing more green space coverage and higher quality of public spaces were ranked of similar importance to its flood mitigation role. This indicates that the impact of GI in property values is more likely to be higher than grey infrastructure, given its multi-functional benefits, which complement its risk mitigation role, of which the general public might not be completely aware and informed. Indeed, 83% of the respondents assume that the values of their properties would increase with the implementation of sponge city, and half of them believe that this increase would be in the range of 2%-11%.

Indeed, proximity to green areas and pleasant landscapes can increase property values substantially, in some cases up to 117% in the case of Centennial Olympic Park, in Atlanta (American Planning Association, 2002). A study for the city of Turin reveals that the real estate prices can differ as much as +143% in areas very close to one another and with similar accessibility and distance from the city centre (D'Acci, 2018). Additionally, it was estimated that the real estate values decrease with 0.23% for each 1% increase in distance from city centre whereas they increase by 0.58% for each 1% increase in the quality of life[3]; attesting for a higher impact on property values of the quality of life than distance from city centre.

Ultimately, there is a growing body of literature that confirms the positive impact of the multi-functional benefits of green infrastructure, in terms of increased flood resilience as well as quality of life, in the property market. Yet, not enough has been achieved in exploring mechanisms through which this potential economic value created by GI implementation can be captured by public authorities to provide alternative ways of financing GI.

Land value capture and Flood Risk Management

Land Value Capture (LVC) has been widely investigated as a means to finance infrastructure and promote sustainable urban development. Conventional ways of providing infrastructure and services neglect the uneven distribution of costs, mostly covered by general public contributions, and benefits, largely obtained by landowners through windfalls (Smolka, 2013). In this regard, the goal of land value capture is to mobilize some or all of the increment in land value, which results from any effort other than that of the landowner's, for public use. Such increments might be the result of improvements in infrastructure and services in the proximity of the benefiting properties, or changes in land use and regulations which provide more development rights for certain properties.

Land value capture instruments are very diverse and some of them have been implemented for a long time, although not specified as LVC per se, but rather in the realm of taxes, fees or land management instruments. The table below is an attempt to summarize and classify the various LVC instruments and map their implementation internationally. Given the variety of instruments and practices, and their historic implementation, this summary is by no means comprehensive, but rather a general overview of LVC and the documentation of their implementation in literature.

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[3] In the cited study, the quality of life is calculated as the arithmetic average of factors such as: green, shops, quality of streets, buildings, squares, agreeable pedestrian areas and social context

TYPE	INSTRUMENT	BRIEF DEFINITION OF THE INSTRUMENT	EARLY PRACTICES	TYPES OF PROJECTS FINANCED	LOCATIONS	MAIN CHALLENGES
Financial/ Fiscal Instruments	**Betterment levies/ Special assessment**	A fee charged on the incremented value of a property attributable to a public investment Betterment levies are charges on real estate property owners who benefit from infrastructure improvements	1691 - New York	Infrastructure (mostly transport/road network)	Colombia Most countries in L.America have it in the law	* Definition of benefit area * Value increment attributable to public effort * Impact it has on real estate prices
	Developer exactions and Impact Fees	Developer Exactions: Developers required to install at their own expense internal infrastructure Impact Fees: For projects forecasted to have significant impacts on infrastructure beyond the project development areas	1970 North America 1990 UK Town&Planning act	Infrastructure	North America Chile UK (section 106) Guatemala Argentina Colombia Brazil	*impact fee formula
	Property tax	The Property Tax is a tax imposed by local government on the ownership or occupation of property.	Antiquity - Egypt, Persia, Babyllon, China 1st Cent BC - Roman Empire	It is usually not earmarked (can be used for different expenditures)	Almost in every country worldwide.	*Land vs. Improvements tax *Property value assessment
	Tax increment Financing/ Business Retention Strategy BID, TID	Consists in using the future flow of property tax increases generated by a public intervention to finance its costs	1952 - North America	Urban Upgrading/ Transformation	North America United Kingdom	*allows recovery of only a small portion of the value created *contributes to asymmetric service distribution

Urban Transformation	**Land Readjustment/ Land pooling**	Allows the merging and reconfiguration of lots in a given area in accord with a plan that increases their value and provides the land necessary for public uses	1791 - Washington DC 1934 - South Korea	New developments in periphery Slum upgrading Urban transformation Post-disaster recovery	Germany South Korea Japan	*Takes a long time *Citizen participation is crucial
	Cooperative Land Banking	CLB separates the private ownership of buildings from land ownership, with all the land becoming owned by a cooperative controlled by its residents. The double tenure created allows CLBs to capture the uplift in land values from urban development, which can then be used to make the cost of sites and services self-financing.	19th Century UK	Internal infrastructure and services within the CLB	UK	*Redefining the nature of property rights on economic basis
	Community Land Trusts	A community land trust is a non-profit organization formed to hold title to land to preserve its long-term availability for affordable housing and other community uses	1984 - Burlington	Social Housing	North America	*Depends on initial donation of land & operating grants
	Land Sharing	An innovative model of urban redevelopment and slum upgrading through sharing of land between profitable (commercial) developments and social housing for informal dwellers.	1970s - Thailand	Social Housing Internal infrastructure inside the land sharing area	Thailand Cambodia	*Requires a booming property market *Well established communities *Community organization and consensus *Intermediation from third parties *Appropriate physical/technical and financial feasibility studies

Asset Management	**Public Land Management/Sales**	Land sales represent a special form of capital revenue, which can be used to help finance general capital expenditures (usually related to new infrastructure)	1970 - World Trade Development Center (financed from land sold from Port Authority)	Major Infrastructure projects New developments Social Housing	US Denmark Netherlands Egypt	*Transparency and accountability *Short term instrument- limited impact
	Public land leasing	Revenues generated from leasing of public land with market prices can be used to cover infrastructure investment needs	China	Transport/Road infrastructure	China	*Applicability depends on the amount of public land available *Transparency and accountability
	Land Acquisition and Resale/ Compulsory purchase of land	Capturing the value created from acquiring private land, investing in infrastructure and selling of the remaining land at higher prices to cover infrastructure costs	1853 - Paris	Infrastructure	UK France	* Limitations on the powers of public authorities to purchase land not needed for public works
Other	**Transfer of Development Rights**	TDR severs the development value from the property and allows the owner to realize that value through more extensive development of other property.	1961 - New York 1995 - Sao Paulo	Historic and Environmental Preservation Flood Risk Mitigation	North America Brazil	* the value of the transferable development rights uncertain *Is TDR a just compensation

Table 1 Summary of LVC instruments applied internationally (Source: Table compiled by author based on Harrow, 1929; Peterson, 2009; Dye and England, 2010; Vetter and Vetter, 2011; Smolka, 2013; Blanco *et al.*, 2017; Salm, 2017)

Although experience with engaging LVC to finance GI is lacking, the scope of some LVC instruments have expanded with time to accommodate environmental objectives. The section below scrutinizes Transfer of Development Rights, an instrument initially used for historic preservation purposes, and later on adopted for the implementation of environmental protection agendas. Recent practices of TDR can be a starting point for further research on how this instrument can contribute to alternative financing for GI.

Transfer of development rights as a Land Value Capture instrument

Transfer of development rights (TDR) (or air rights/density transfer/purchase of development rights) is an instrument that falls under the Land Value Capture instruments utilized for providing more sustainable and environmentally resilient urban areas. TDR builds on the idea that property rights exist as a separable bundle of rights, such as the right to use, to farm, to build, to mine and the like, which can be transferred and/or can be made available for market transactions (Kaplowitz, *et al*., 2008; Nelson *et al*., 2012). TDR focuses especially in the right to develop and considers this right transferable from designated "sending areas" to designated "receiving areas".

TDR operates under specific legislation that allows additional development potential in areas deemed appropriate for densification or other types of development benefits, defined as "receiving areas", which developers can take advantage of when they provide in cash or in-kind benefits for off-site public benefits or compensation for off-site land conservation, in areas defined as "giving areas" (Pruetz, 2016). The specific legislation addressing the implementation of TDR is combined with zoning and/or land use regulations. Such legislation should regularize additional development rights in receiving areas, considering the maximum carrying capacity of receiving areas, as well as mechanisms of transferring such development rights from giving areas; be it through the creation of Banks or other mechanisms.

Traditionally used as an instrument to preserve farmland and environmentally sensitive areas, currently TDR practices have expanded their scope to serve various local government planning goals, such as creation of parks, green infrastructure, scenic views and landscape preservation, trails and other community benefits (Nelson *et al.*, 2012; Puertz, 2016). Areas where such services are to be provided are defined as "giving areas", where landowners, either voluntarily or compulsorily, participate in the program by selling their development rights to developers in "receiving areas", either through direct negotiation, through the mediation of the local government or through a bank. Once this is carried out, a legal instrument is registered with the property deed in the giving area which permanently limits or freezes the development of land, in fulfilment to the predefined planning goals. This legal instrument is generally referred to as a conservation easement (Puertz, 2016).

Receiving areas are areas where densification can occur beyond a predefined baseline. The bonus development can refer to residential density, additional land coverage, height, or other modifications that developers might deem as desirable. Evidently, the motivation to participate in the program should derive from extra benefit created for developers, having covered the costs of participating in the TDR program and of providing bonus development (Puertz, 2016). TDR legislation includes methods and formulas to calculate the maximum TDRs that can be accommodated in receiving areas and to establish a TDR value that is attractive to both developers in receiving areas and landowners in sending areas. It is important to bear in mind that TDR programs do not intensify development but rather redistribute according to more sustainable development models (Chiodelli and Moroni, 2016).

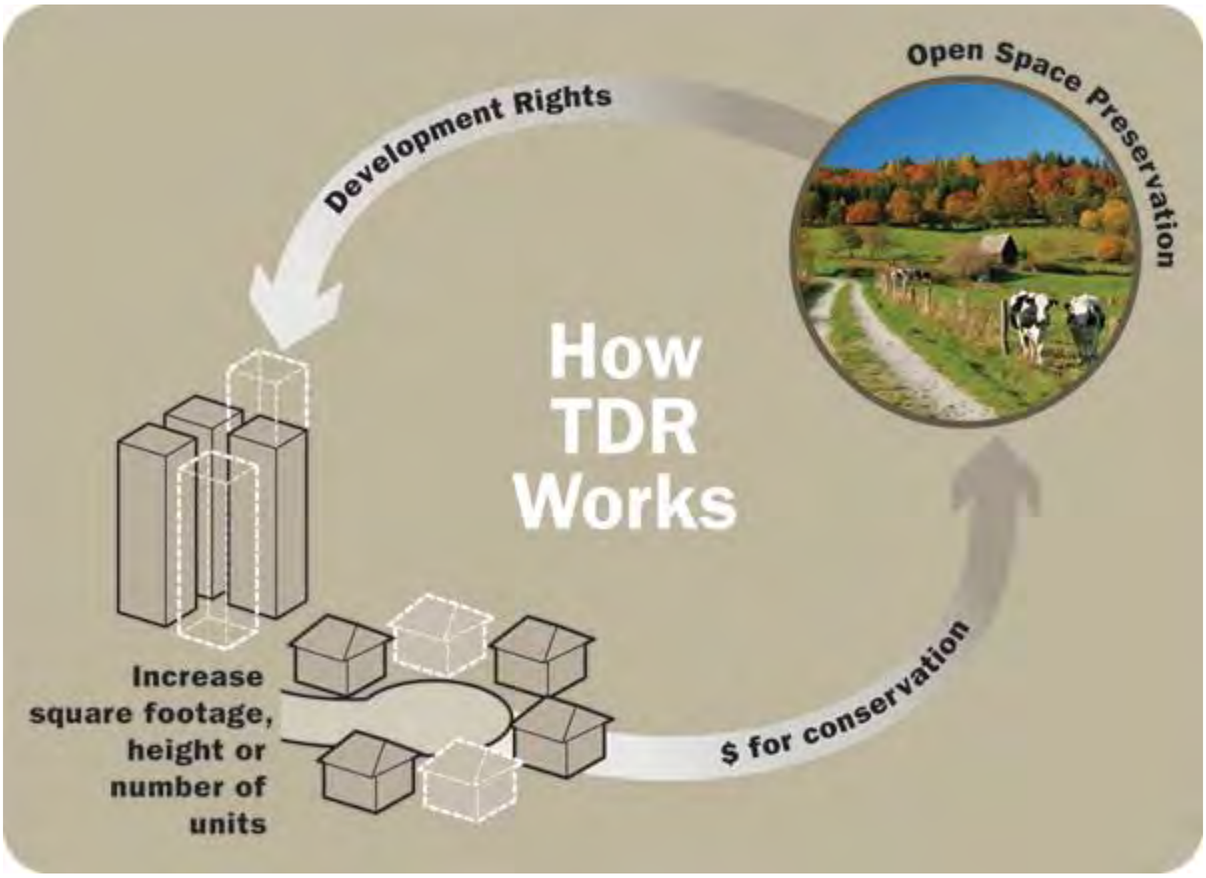

Figure 1 Infographic on how TDR works (Source: King County, retrieved from https://www.kingcounty.gov/services/environment/stewardship/sustainable-building/transfer-development-rights/overview.aspx)

One challenge of managing TDR programs is that the timing of issuance of TDRs in sending areas might not coincide with the timing of TDR purchase from developers in receiving areas. Hence, separation of TDR extermination from acquisition has called for intermediary institutions such as development rights banks (Stinson, 1996; Puertz, 2016). Indeed, TDR banks buy, hold and sell development rights to facilitate the process and create a mechanism of perpetually investing in TDR purchase in giving areas and support land conservation. For instance, TDR bank in King County, Washington, initially purchased TDRs using property tax revenues, and invested the proceeds from the sale of these TDRs to further purchase TDRs in other areas "…converting what would otherwise be a one-time use of public money into a perpetual revolving fund for preservation" (Puertz, 2016, p.5).

Facilitating Green Infrastructure provision through TDR

Stinson (1996) suggests that there are three main concerns that brought about TDR programs: pressure to develop historic landmarks, higher demands for open spaces in congested metropolitan areas and economic incentives to develop environmentally sensitive areas. TDR addresses such pressures by reconstructing the economic incentives in land use. Indeed, the first TDR program sought to address the challenges of preserving historic landmarks in the high-pressure building market of New York in the early '60s (Stinson, 1996). Over time, many TDR programs were adopted to fulfil several development goals of local governments, many of which lean towards mitigation of climate change induced risks. Up to date, more than 320 cities around the world have implemented TDR programs, 283 of which in US, while the rest in 11 other countries such as Australia, Brazil, Canada, China, France, India, Italy, Japan, Mexico, Spain, and the Netherlands (Pruetz, 2016). More than half of these programs were designed to address environmental challenges and protect natural resources (Nelson *et al.*, 2012). Although the experience with TDR programs for flood risk mitigation is limited, such cases attest for the untapped potential of this instrument. Some coastal TDR programs, initially designed to protect the ecosystems of environmentally sensitive areas, have expanded their objectives to target adaptation to seal level rise. For instance, 13 out of 20 counties in Florida that have implemented TDR programs are coastal counties (Linkous and Chapin, 2014).

The High Line project in New York is a very accurate example of how a major GI can be implemented through the facilitation of TDR. The High Line consists of a public park built on top of an abandoned elevated train line, the implementation of which was rendered possible through a TDR program as part of the Special West Chelsea District in 2005. This TDR program unlocked the development rights of the giving area, namely properties underneath and immediately to its west of the high line, by encouraging their transfer to the receiving area, mostly focused on nearby Avenues 10 and 11 (City of New York, 2015). Receiving areas could increase their FAR up to 1 in some subareas and 2.5 in others. Through this program the city was able to provide an open corridor with numerous positive externalities in terms of environmental benefits and improved quality of life.

Figure 2 Figure 2 New York City High Line Park (Source: Picture on left retrieved from: https://www.npr.org/2011/09/03/140063103/the-inside-track-on-new-yorks-high-line , Picture on the right : https://www.timeout.com/newyork/parks/highline)

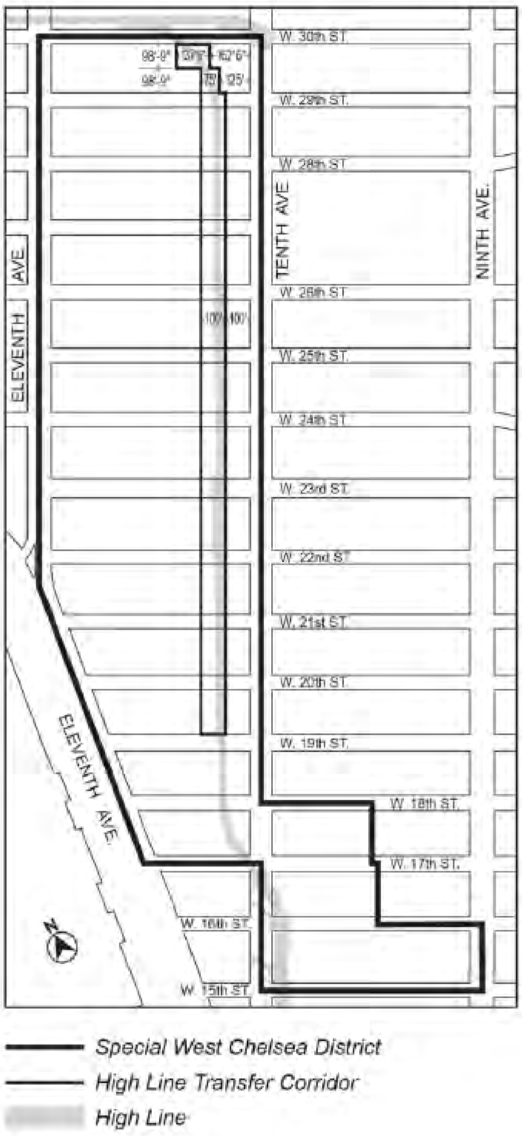

Figure 3 High Line TDR program (Source: City of New York, retrieved from: https://www1.nyc.gov/assets/planning/download/pdf/plans-studies/transferable-development-rights/research.pdf)

While the standard measure of the success of TDR programs is the overall surface area of land conserved in giving areas, the Florida experience of TDRs evolved during 90's and 2000's towards further sophistication of the market of transferable rights and receiving area development. Ultimately, the success of TDR programs relies largely on the additional profits that developers take advantage of by participating in the program in the receiving area. Henceforth, refining the calculation of the developers' demand to exceed baseline development in receiving areas becomes central to the success of a TDR program (Puertz, 1997). However, whilst a couple of decades ago profits were linked with more square meters developed, today other modifications in the development, which might improve the quality of life and attractiveness of the area can be equally important. In this sense, the impact of GI in the market values of the nearby properties can be translated in increased potential to absorb more development right, but also in higher market values of the same development rights. Balancing windfalls on properties benefiting from the implementation of GI with property blight of the properties whose development is limited or frozen because of the implementation of GI should be the next step of research towards new models of TDR programs.

Conclusion

Traditional grey protective infrastructure against flood risks are no longer enough to address the challenges that climate change is posing in many urban areas. Green Infrastructure is promoted as solution to more environmentally resilient cities based on a more holistic approach to understand and address the complex dynamics of social-ecological systems (Hansen and Pauleit, 2014). Within the last few years, GI has become popular with policy makers and public authorities as a way to integrate land uses in a more sustainable way. Its multifunctionality, including provision and connection of open spaces and green areas, makes GI even more attractive for the public, which might not always be aware of how GI contributes to ecosystem services and towards mitigating flood risk. Indeed, the study conducted in Wuhan revealed that when it comes to infrastructure for flood protection, citizens are more willing to pay for GI provision because of its effects on the quality of life and landscaping benefits, rather than because of its contribution to flood risk mitigation; a risk which many citizens are often not aware of or underestimate (Zhang *et al*., 2018).

Empirical research on the impact of GI in land markets is still in initial stage, however studies on the factors that affect the demand side show that the quality of life and the quality of urban environments are becoming increasingly important factors, especially in the recent years when the effect of distance as a factor is decreasing due to technological advances and changes in lifestyle. Studies in cities in different contexts around the world, such as the experience in US, China nd Italy, all show that the willingness to pay from the demand side, especially in residential areas, increases substantially when the quality of life, an important part of which are open and green spaces, improves in a given area (American Planning Association, 2002, D'Acci, 2018, Zhang *et al*., 2018). The advantage of GI is that it provides open and green spaces, combined with other functions in terms of ecosystem benefits and increased environmental resilience towards extreme weather conditions. How can public authorities capitalized on this added value of GI, in terms of land market appreciation, to finance such infrastructures? This is a question that deserves more attention in public policy and academic research. The existing experience with Land Value Capture in financing mostly road infrastructure and public transport projects, can be transferred when it comes to GI provision for flood risk mitigation purposes. Transfer of Development Rights, an LVC instrument with an emphasis on land conservation, can be an attractive instrument in terms of cross-subsidizing property windfalls of the properties benefiting from GI and property blights of the landowners in properties where development shall be frozen to provide GI. TDR requires attractive land markets to subsidize land conservation and perpetually freeze development for GI provision. The positive impact that GI has on land markets of the beneficial areas presents an incentive for such areas to be designated as receiving areas, where additional development rights can be transferred to. Further research should explore such new models of TDRs and the legal, institutional and financial implications of implementing them for GI provision.

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