IMPROVING HOUSING RESILIENCE

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GLOBAL PROGRAM
RESILIENT HOUSING

SYNTHESIS REPORT

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This Synthesis document was produced by Luis Triveno, Gabriel Arrisueno and Sarah Antos based on (i) the technical work produced by Build Change, Miyamoto International, SARC, Development Seed, Analisis Geograficos SAC, Alejandro Cantera, Carlos Ariel Cortes, Elena Tames and Salvador Herrera; and (ii) the data collection effort that the team conducted in the Istmo de Tehuantepec Region in Oaxaca.

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Carina Lakovits, Phoebe Spencer, Miguel Rodriguez and Jonathan Hasoloan, provided support during the data collection and/or the elaboration of this report.

The drone imagery was produced by Adam Benjamin.

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Claudia Pacheco and Diana Jimenez provided logistic support.

The data presented in this document has been obtained from official sources that we consider reliable. Estimates have been produced based on conservative assumptions. The drone and street-view imagery, training data and algorithms are all open-source and available upon request.

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FOR THOSE WITH THE LOWEST INCOME LEVELS, THE QUALITY OF THE HOUSING SOLUTIONS OFFERED IN THE MARKET IS TOO LOW AND THE UNITS ARE TOO SMALL AND DISTANT.

EXECUTIVE SUMMARY

This synthesis report summarizes the main findings of the MX Improving Housing Resilience ASA (P169278). The ASA was prepared to provide technical guidance to the National Housing Commission (CONAVI) and the Ministry of Agrarian, Land and Urban Development (SEDATU) in their efforts to increase resilience by (a) improving the targeting of housing subsidies; (b) strengthening municipal urban management and (c) improving the design and implementation of CONAVI's existing home improvement subsidy scheme.

Mexico has developed a solid legal and institutional housing framework over the past decades and made significant progress in terms of expanding access to formal and affordable housing. Mexico's housing policy has been successful in increasing access to housing for low and middle-income families, through the provision of targeted technical assistance and increased access to housing loans or microcredits. The creation of the National Housing Commission (CONAVI), the adoption of a new housing law in 2006 and the introduction of a demand subsidy program targeted at low-income families by CONAVI all contributed to expanding access to affordable housing in Mexico.

However, important challenges in terms of meeting existing housing needs in Mexico remain. In 2016, according to the SNIIV Mexico had a housing deficit of 9.2 million households, which represented 28% of the total number of households estimated for that year (32.8 million). The housing deficit among indigenous communities is severe, reaching 79.1% according to CONEVAL. Households headed by women, the elderly or disabled are particularly likely to live in inadequate homes (CONEVAL, 2018). In terms of targeting, most housing subsidies were provided to formal workers affiliated to the social security system. In 2016, 68 million Mexicans (53% of the population) were not affiliated to the social security system and therefore ineligible to receive loans from entities such as INFONAVIT or FOVISSSTE. In addition, the share of housing finance targeted at self-construction –the main way the poor access housing– remains very small. In the period 2007-2019, only 14% of CONAVI's subsidies went towards self-construction (CONAVI, 2019).

Exposure to natural and climatic disaster risk exacerbates the precariousness of people's housing. Around 41 percent of Mexico's territory and 31 percent of its population are exposed to hurricanes, storms, floods, earthquakes, and volcanic eruptions. In economic terms, this translates into 30 percent of GDP considered

HOUSING POLICY IN NUMBERS

1973-2018

- **45** years.
- **122** entities.
- **30.4 million** of housing actions.
- New housing: **52%** of the housing actions, 88% of the budget.
- Home improvement: **40%** of the housing actions, **4%** of the budget.
- Other: **8%** of the actions, **8%** of the budget.

SOURCE: CONAVI

*There are **5 million** abandoned homes in Mexico. **80%** abandoned due to bad location and lack of access to jobs, education and health services.*

AN EXAMPLE OF MEXICO'S PIONEERING HOUSING SOLUTIONS

Piso Firme Program offered households with dirt floors up to 50 square meters (538 square feet) of concrete cement flooring.

IMPACT:

- Reduction in diarrhea **(49%)**, anemia **(81%)** and parasitic Infestations **(78%)** In children.
- Reduction in depression rates **(52%)**, increase their satisfaction with their homes **(59%)** and their lives **(69%)** in adults.

HOUSING ACTIONS

Subsidies and Loans

YEAR	TOTAL ACTIONS (MILLION)	TOTAL (USD BILLION)
2007	**1.27**	**13.2**
2008	**2.01**	**14.2**
2009	**1.66**	**12.3**
2010	**1.74**	**12.9**
2011	**1.59**	**12.9**
2012	**1.78**	**13.2**
2013	**1.42**	**13.9**
2014	**1.38**	**16.1**
2015	**1.37**	**17.0**
2016	**1.26**	**17.4**
2017	**1.17**	**18.0**
2018	**1.22**	**18.5**
2019*	**0.47**	**8.65**
TOTAL	**18.35**	**188.3**

* Until June 30th, 2019

SOURCE: SNIIV

*Mexico: **64.2%** of housing units were self or incrementally built with or without technical assistance.*

*The 6 States that explain **48.2%** of the housing deficit (2016), concentrated **24.4%** of the housing actions between 2007 and 2018.*

to be at risk from three or more hazards and 71 percent at risk from two hazards or more. Today, 7 out of 10 Mexican live in areas of high natural and climatic disaster risk. The location of housing in high risk areas, and the precarious structure of dwellings, exposes especially vulnerable groups and low-income communities. As more and more people move to the cities, the percentage of people living in areas exposed to floods, landslides, tsunamis and other natural phenomena continues to increase.

For low-income Mexican families already with limited access to mortgage markets, self-construction and incremental housing have become the preferred solutions to their housing needs. However, the quality of this type of housing is often low, with units small and distant. Furthermore, the neighborhoods lack basic services, green spaces and access to jobs, education and health services. Mexico's high number of abandoned homes suggest that that these homes were not built where they were needed: according to INEGI, there are 5 million abandoned homes in Mexico. For low-income Mexican families already with limited access to mortgage markets, self-construction and incremental housing have become the preferred solutions to their housing needs.

The Mexican Government that took office in January 2019 redefined the focus of Mexico's housing policies and prioritized reconstruction, resilience and social inclusion as its most important objectives. This renewed focus will enable to the government to reach the poorest and most vulnerable populations that so far have largely been excluded from official housing assistance programs. The aim is to address existing geographical imbalances in the provision of housing assistance; improve the institutional support for home improvement and housing retrofit; and strengthen household-led self-construction processes, amongst others.

In order to assess the vulnerabilities of the housing stock and identify opportunities for simple, affordable and effective housing retrofit, the World Bank conducted a pilot intervention in selected municipalities of the Istmo de Tehuantepec region of Oaxaca. The Bank team customized the methodology developed by the Global Program for Resilient Housing to capture detailed information about the housing stock and identify opportunities for strengthening existing structures and other improvements. The aim was to test a methodology that could be scaled up and replicated in other parts of the country, particularly regions exposed to high natural disaster and climate risks. This pilot intervention was complemented by an extensive review of the Mexican experience of providing housing assistance to identify what works and what doesn't work in public housing assistance for the poor and most vulnerable.

The piloted approach combines the application of geospatial technology to characterize the housing stock and assess its levels of vulnerability, analysis of census data and hazard risk maps,

OPPORTUNITIES TO CLOSE THE INSTITUTIONAL, POLICY AND RESOURCE GAPS

INSTITUTIONAL GAP	POLICY GAP	RESOURCE GAP
Strengthen interinstitutional coordination.	Calibrate the portfolio of housing subsidies.	Establish a comprehensive diagnostic of the housing sector in the country.
Strengthen hazard and planning information and integrate housing and urban policies.	Adjust housing assistance programs to effectively address housing needs of the most vulnerable segments of the population.	Adopt a robust and simple methodology to assess the vulnerability of the housing stock.
Build the capacity at the federal, state and municipal level in the housing and planning sector.	Strengthen housing resilience by integrating retrofit measures into home improvement activities. Prioritize those geographical areas with the largest housing deficits.	Design technically and economically viable self-construction and home improvement instruments.
Strengthen the ecosystem for the provision of specialized technical assistance and tailored housing assistance.	Harmonize and coordinate urban and housing policies, as well as housing retrofit interventions with urban upgrading and other programs.	Promote financial inclusion by designing savings, credit and insurance instruments that suit the needs of the different population segments.

and selective qualitative assessments to provide a picture of the reconstruction and retrofit needs in the area with an unprecedented level of detail. All existing hazard maps were reviewed and integrated in a single geospatial database. In addition, drone imagery captured roughly 30 sq km of land, and street view cameras captured 580 km of road. To identify potential alternatives for structural strengthening, more than 100 general and 40 detailed engineering assessments were performed. Probabilistic risk models were used to evaluate the efficacy of allocating more public funds in an area of interest in Oaxaca (26 districts in Salina Cruz) to making homes safer.

The piloted approach demonstrated that simple retrofit intervention targeting the most vulnerable housing structures could reduce estimated potential losses in case of earthquakes by half. For example, it was found that targeted retrofit interventions focusing on the 18% of unreinforced or semi-reinforced housing units and completing their confinement reduces the estimated potential losses in case of an earthquake by half. Based on these characterizations, the team proved that simple and small investments can, at the same time, improve the quality of life of families and significantly reduce the expected losses in the event of a disaster.

Based on the review of Mexico's experience of providing housing assistance and the findings generated by the successful pilot intervention in the Istmo de Tehuantepec region, the Team arrived at the following conclusions:

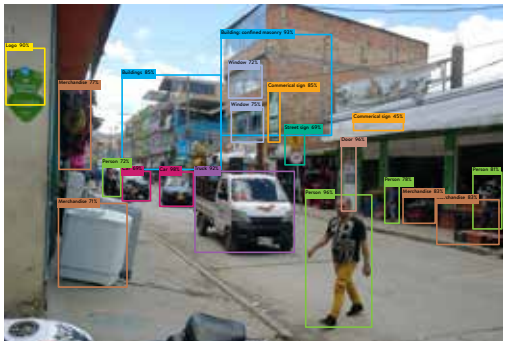
- The Mexican government has correctly identified the need to focus on sustaining reconstruction efforts and promoting resilience and social inclusion.

- However, the Government needs to address three major gaps in the country's housing assistance framework for its new strategy to succeed; these include: (i) an institutional gap, which hinders inter-agency coordination, effective policy implementation and private sector participation; (ii) a policy gap, characterized by uncoordinated housing and urban policies, shortcomings in the design of housing subsidies and assistance programs, and a lack of policy provisions for residential retrofitting; and (iii) a

THE COMPONENTS OF THE METHODOLOGY FOR HOUSING DATA CAPTURING

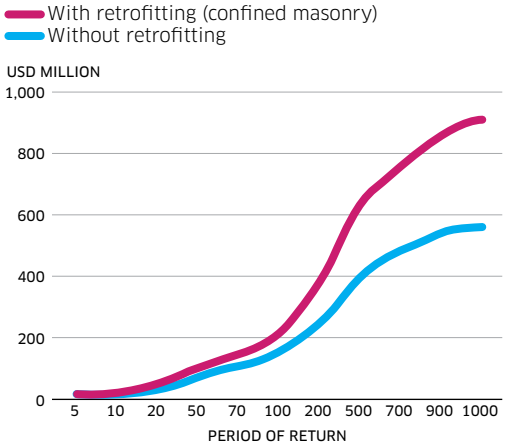
Drone imagery.

Street view imagery.



Machine learning.

THE POSITIVE IMPACT OF RETROFITTING



Confined masonry

Unconfined masonry

HOUSING UNITS AFFECTED BY THE 2017 EARTHQUAKES

FEDERAL STATE	HOUSING UNITS	
	PARTIAL DAMAGE	TOTAL DAMAGE
Estado de México	**6,059**	**2,468**
Morelos	**5,765**	**2,273**
Puebla	**27,812**	**3,214**
Oaxaca	**63,336**	**21,823**
Chiapas	**59,397**	**18,058**
Tlaxcala	**34**	**0**
Guerrero	**2,976**	**1,451**

SENATE FROM MEXICO, 2017.

AN EXAMPLE OF A STATE IN THE SOUTH

- **Housing deficit in Chiapas: 78.2% of the total.**
- **In rural housing: 96.5%.**
- **In indigenous communities: 79%**

resource gap, referring to a lack of available data and analysis about the housing stock, as well as need to expand the toolbox of the Government to tailor housing assistance mechanisms to the needs of the most vulnerable population and expand access to flexible financial services to those most in need.

- The Government can close those gaps by leveraging the experience and reach of Mexico's institutional setting, the lessons learned through decades of implementation of home improvement programs, international efforts at house retrofitting, along with the existing hazard information and the application of new technologies and geospatial data collection methods. The intervention in the Istmo de Tehuantepec piloted an innovative methodology that could help CONAVI and SEDATU reach the most vulnerable segments of the population with a strong value proposition, namely one that combines legal and physical security, quality of life and social welfare. It was found that through simple yet targeted home improvement and retrofit interventions, household's exposure to risk could be reduced by half. At the same time, the data and information generated by this methodology about the living conditions of the beneficiaries can inform government programs in other sectors.

- Budget constraints on government spending, including in the housing sector, highlight the need for an active participation of the private sector (households and companies). This is consistent with international best practices, which show that structural reinforcement programs can incentive private participation if properly designed and communicated.

- The Bank's methodology used in this ASA confirmed that achieving these goals is affordable, reliable, and scalable. The necessary fieldwork, which we conducted in Oaxaca in just weeks, could be replicated in the States that have been designated as priorities in the National Reconstruction Program (Puebla, Guerrero, Morelos, Chiapas, Mexico, Oaxaca); as well as the States in the South which concentrate the country's poorest populations (Oaxaca, Chiapas, Guerrero, Veracruz, among others).

- Experiences from countries with extensive data on housing risk management, such as the United States and Japan, indicate that it is key to use cutting-edge technology complemented with other sources of information, to identify risks and report an efficient allocation of resources for prevention. Acceptance of stakeholders is essential; the design and execution of effective communication and coordination strategies must be a priority; as well as carrying out strengthening activities to improve regulatory capacity; offer a flexible menu of financial assistance schemes; maintain a long-term horizon for housing programs; develop and update regulatory instruments such as codes and guidelines; and pilot innovative schemes that allow gradual adjustments to existing programs.

THERE IS A CLEAR OPPORTUNITY TO DESIGN INNOVATIVE HOUSING SOLUTIONS CAPABLE OF REACHING THE BOTTOM-40 SEGMENT OF THE POPULATION.

For future Bank engagements in Mexico, there is a clear opportunity to work together with authorities (i) to preserve and leverage the solid institutional framework in the housing sector that Mexico has developed in recent decades; (ii) to design innovative housing solutions capable of reaching the bottom-40 segment of the population; and to (iii) help the country to expand its infrastructure –instead of continually having to rebuild it after disasters.

FOR THE MOST VULNERABLE, THE "MEXICAN HOUSING MIRACLE" IS STILL A PROMISE UNMET.

1. The Challenge

Mexico is well-recognized in Latin America for its success in expanding the supply of formal and affordable housing in the face of rapid urbanization: between 1950 and 1970, Mexico's urban population more than doubled. Over the past 45 years, due to the action of multiple public and private institutions, more than 30 million homes in Mexico have been built or improved through different financing mechanisms. In the last 12 years alone, a total of USD 182 billion was allocated to finance the construction or improvement of more than 18 million houses. 80% of financing for home purchases and improvements came from public entities, including public housing funds, and only 18% from private sector finance[1].

These remarkable results, nonetheless, have been insufficient to address the current housing deficit, while accommodating the formation of new households –particularly from the lower income segments of the population or the most vulnerable– in a country where 78% of the people live in cities. And there are reasons for this: in the last 12 years, while 51% of households in the country were classified as poor, only 27% of all housing actions were directed towards them.

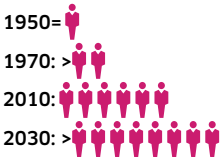
As a result, for the most vulnerable population, such as indigenous people, the "Mexican housing miracle" is still a promise unmet. For example, while 45% of all Mexicans experience a housing deficit, it's 79% among the indigenous. And while only 15% of Mexican households lack access to basic services in their homes, 56% of indigenous households experience this problem. A similar gap exists between formal workers and unaffiliated ones. While only 25% of households where the breadwinners have formal jobs face a housing deficit, almost 75% of the households where unaffiliated workers live face this problem.

For those Mexicans with access to mortgages, the greater availability of housing finance significantly improved their quality of life. In some cases, though, not so much. The construction boom driven by private housing developers led to significant urban sprawl in the outskirts of Mexican cities where land prices were low and economies of scale achievable. The reason is relatively simple: it is estimated that land in Mexico's major cities represents between 6.8% and 18.2% of the total housing project cost (SHF and CIDOC, 2015); however, in consolidated areas of the largest cities, land could represent up to 50% of the total housing project cost (SEDATU, SEMARNAT and GIZ, 2017).

As a result, many housing developments that emerged during this period were so distant from urban amenities and other public services, including transport, water and sanitation, that often fami-

[1] CONAVI, SNIIV, 2019.

POPULATION GROWTH (%)



URBAN GROWTH: 2010-2030

CITY HIERARCHY		2010	2030
Mega City	10 million	1	1
Major Cities	1 to a 5 million	10	17
Intermediate Cities	500k to 1 million	22	18
Medium Cities	100k to 500k	62	76
Small Cities	50k to 100k	40	102
Urban Centers	15k to 50k	249	747
TOTAL		**384**	**961**

THE HOUSING DEFICIT IN MEXICO

In 2000, the housing deficit was estimated to be **44.9%** of the housing stock.

	% OF TOTAL	MILLION OF UNITS
SNIIV, based on census data 2015*, own methodology	**28.1%**	**9,2**
Federal Mortgage Society, based on census data 2015, own methodology	**28,1%**	**9,2**
National Housing Program 2014-2018, based on census data, 2012	**49%**	**15,3**
Coneval, based on census data, 2015, own methodology	**44.7%**	**14**
UN Habitat 2018, based on their own estimations	**38%**	**12,6**

* https://www.gob.mx/cms/uploads/attachment/file/444719/Rezago_habitacional_2016.pdf

HOUSING DEFICIT: 2016

Percentages of the total for each category.	
Urban	**38.5%**
In transition	**18.0%**
Rural	**43.5%**
Affiliated	**25.5%**
Non affiliated	**74.5%**
From 0 to 2 MW	**41.5%**
From 2 to 4 MW	**32.8%**
From 4 to 6 MW	**13.9%**
From 6 to 8 MW	**5.7%**
From 8 to 10 MW	**2.6%**
10 MW or more	**3.5%**
Active	**92.0%**
Inactive	**8.0%**

SOURCE: SHF BASED ON MCS 2016 INEGI.

ALLOCATION OF PUBLIC FUNDS TO HOUSING BY LOCATION: 2014-2017

Of 2.2 million new homes constructed:	
Outside of the urban perimeter zones	**21.%**
Peripheral Zones (PCU 3)	**43.6%**
Consolidates Zones (PCU2)	**26.9%**
Urban Core (PCU1)	**8%**

SOURCE: UN HABITAT BASED ON CONAVI, 2018.

***41%** of Mexico's territory and **31%** of its population are exposed to hurricanes, storms, floods, earthquakes, and volcanic eruptions.*

lies simply abandoned them. In a survey of its borrowers conducted by INFONAVIT in 2015, for example, almost half expressed dissatisfaction with the quality of life in the new housing developments[2].

According to a 2017 study by CONEVAL based on the interpretation of census data, five million houses, or 14% of the housing stock in Mexico, were unoccupied. More than 90% of these houses were located in urban areas. According to INFONAVIT, 80% of its non-performing loans are linked to housing developments in the outskirts of urban areas that are not only overcrowded but also disconnected from employment opportunities[3].

The introduction of the city perimeters program *(Perímetros de Contención Urbana, PCU)* in 2014 –aimed at directing government-backed mortgages to city centers– was an attempt to address this imbalance. But it was only partially effective because the value of the subsidies could not compensate for the increase in land values in the urban core. Of the 2.2 million housing units financed by the public housing funds between 2014 and 2017, only 8% were located in consolidated areas of the city (PCU1). Only 3% of the housing units intended for low-income residents (vivienda económica for those earning below 2.6 UMAs) were located in the PCU1 (ONU-Habitat, 2018). In contrast, the homes for those better-off *(vivienda media and vivienda residencial)* were predominantly located in well-consolidated areas (52%), with only a fraction of them (12%) built outside the PCU.

Faced with a housing supply that was insufficient, unaffordable or unsuited to their needs, city newcomers continued building their own dwellings, without government assistance. They relied on available materials and workers, building their homes incrementally, as financial resources became available. According to the National Household Survey, **68% of houses in Mexico are built through incremental self-construction** (ENIGH, 2010). As land becomes scarce and more expensive, mirroring what has happened in the formal sectors, families start settling in distant areas disconnected from jobs and services, thus exacerbating social and spatial segregation. Those at the bottom of the income distribution are often left with no option but to occupy areas highly vulnerable to hazards such as floods, tsunamis, and earthquakes. 41% of Mexico's territory and 31% of its population are exposed to hurricanes, storms, floods, earthquakes, and volcanic eruptions[4]. While those lucky enough to find a relatively safe spot often end up building unsafe homes, due to budget restrictions and lack of access to technical expertise to make their homes resilient.

While different sources disagree on the exact size of the housing deficit, three things are crystal clear about Mexico's housing challenges:

[2] Survey of Satisfaction of the Accredited, cited in What works and what does not in housing?

[3] INFONAVIT, 2014, cited in UN Habitat, 2018.

[4] "Strengthening DRM in Mexico" (P146241).

First, the reduction in the qualitative deficit deserves more attention. According to the SHF, out of a housing deficit of 9.2 million, 19.3% is due to by overcrowding; 78.5.% is due to low quality of materials; and 2.2% is due to the lack of a toilet inside the house. The most important improvements required are related to walls, roofs and floors that need to be reinforced or replaced, the lack of bathrooms or sanitary installations, and insufficient living space. Most of these shortcomings could be addressed through simple, affordable and quick fixes, home expansions or self-construction; only a minority of homes would need to be replaced by new units (3.4%). Thus, the reasonable way to proceed would be to allocate funds to help these families improve their existing homes. Between 2008 and 2016, however, 48.5% of the number of subsidies and loans and 89.6% of the resources, were directed to the acquisition of a new housing unit. The characteristics of the products and incentives in the market show a concentration in the allocation of resources in favor of home purchases: on average, the resources available from subsidies and loans to buy a new home were USD 20,900; and to build your own home USD 7,000. To improve a housing unit, residents received average subsidies of only USD 1,270.

Second, a focus on the more vulnerable would require new geographic priorities and improved operational rules. Even if housing programs have reached and improved the lives of millions, they have also bypassed the most vulnerable segments of the population. In addition to the disadvantageous situation of the indigenous population, households headed by women, the elderly or disabled are particularly likely to live in inadequate homes (CONEVAL, 2018). In the meantime, most housing subsidies were provided to formal workers affiliated to the social security system. However, in 2016, 68 million Mexicans, (53% of the population) were not affiliated to the social security system, according to CONEVAL; and were therefore ineligible to receive loans from entities such as INFONAVIT or FOVISSTE. In addition, the share of housing finance targeted at self-construction –the main way the poor access housing– remains very small. In the period 2007-2019, for example, only 14% of CONAVI's subsidies went towards self-construction (CONAVI, 2019). The Mexican Government could increase its reach to the most vulnerable by: (i) reviewing the size of subsidies allocated for home improvement; (ii) focusing on geographic areas with higher concentration of target groups; (iii) adapting the operational rules to the characteristics of those target groups; and (iv) reviewing its existing tools to incentivize social housing provision in urban centers.

Regarding home improvement subsidies: International best practices indicate that lower property values and incomes would justify higher allocations both in absolute and relative terms. This is particularly important because affordability remains a significant challenge in Mexico and would require targeted adjustments of the subsidy amounts available to low-income households. According to CONEVAL, more than half the households in the country cannot buy a home in the formal market because their income is less than

POOR QUALITY HOUSING

Inadequate housing is defined by a lack of (1 or more of) these criteria:

- Access to water.
- Access to sanitation.
- Sufficient living area.
- Structural quality.
- Durability and location.
- Security of tenure.
- Affordability.
- Accessibility and cultural adequacy.

SOURCE: UN-HABITAT, 2018.

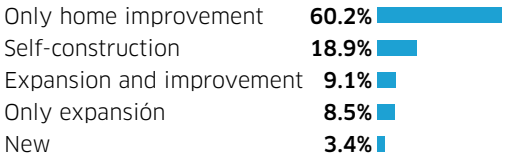
HOUSING DEFICIT WITH TYPE OF MAIN PROBLEM: 2016

COMPONENTS	2016
Housing units	**32,873,588**
With low-quality and overcrowding problem	**9,224,147**
% of total housing units	**28.1%**
% Overcrowding	**19.29%**
	(1,779,034)
% Low-quality materials	**78.49%**
	(7,240,422)
% Toilettes	**2.22%**
	(204,691)

SOURCE: WORLD BANK ESTIMATES.

HOUSING DEFICIT BY TYPE OF SOLUTION REQUIRED

2016 (% of housing units).



SOURCE: CONAVI.

HOUSING NEEDS OF THE INDIGENOUS POPULATION

VARIABLE	% NATIONAL	% INDIGENOUS POPULATION
Housing deficit	44.7	79.1
Needs a new house	11.6	15.2
Needs a better house	33.1	63.9
Low quality materials and lack of space	10.2	30.2
Stoves with Wood or Coal	14.8	58.8*
With property titles	83.7	76.4
With a woman registered as owner	40.8	30.9
Lack of access to basic services inside the house	15.5	56.3
Water connections inside the house	94.5	87.2*
Access to internet	33.0	11.3
Access to any type of phone	84.8	58.2

*CDI: 2017 SOURCE: EIC 2015 AND MEC FROM MCS-ENIGH 2016

MAXIMUM AFFORDABILITY PER FAMILY INCOME

MINIMUM SALARY	RANGE OF MINIMUM SALARY IN USD	MAX AFFORDABILITY (HOUSE VALUE = 5X MINIMUM SALARY)
0-1	From 0 to 135,2	USD 8,112.00
1-2	From 135,2 to 270,4	USD 12,168.00
2-3	From 270,4 to 405,6	USD 20,280.00
3-4	From 405,6 to 540,8	USD 28,392.00
4-6	From 540,8 to 811,2	USD 40,560.00
6-8	From 811,2 to 1.081,6	USD 56,784.00

the government requirement of 5 times the minimum wage. According to CONEVAL estimates, most Mexicans earning below the equivalent of five minimum salaries in Mexico –73 million people (57% of the population) would need some sort of public subsidy to acquire a new home in the formal housing market. Families earning below four or five times the average minimum salary in Mexico would not be able to buy the most popular home option offered by INFONAVIT in recent years (the *Vivienda popular*) –priced at USD 34,000. Nor can they afford home improvement: the average support package for home improvement offered by institutions like CONAVI is USD 1,577) –insufficient considering that the average cost of improving a home in Mexico is USD 2,700.

Regarding the geographical focus, currently 8 Mexican States that concentrate 50% of all the homes in deficit have received only 26% of all housing actions (subsidies and credits). A stronger emphasis on underserved States would be required both through housing subsidies and urban infrastructure investments.

Regarding the operational rules, they would need to be adapted to (i) incentivize private sector participation in geographical areas and with products that are currently not the most preferred; (ii) ensure the technical standards of the interventions; and (iii) avoid excluding large segments of the population that have a high need for housing interventions (eg. the non-affiliated, the elderly, monoparental households, etc).

Regarding the incentives to increase the supply of social housing in central areas: There is ample space to introduce changes that could make the financial numbers work for construction companies and families. A World Bank study conducted in Merida concluded that mixed housing projects including affordable housing in the city center are possible if simple changes in zoning and other regulations were considered, such as the increase of permitted densities, and the reduction of required parking spaces for housing and commercial buildings.

Third, resilience needs to become a central part of the Government's housing policies and programs to ensure sustainability, particularly given how exposed Mexico is to different hazards and climate-related events: One out of three Mexicans are vulnerable hazards and climate related events.

Worse still, there events are becoming more frequent, damaging, and deadly –with the housing sector suffering a significant part of the damages caused by these adverse events. When a catastrophic event occurs, the poor tend to be disproportionately affected; and, since they have fewer assets, they are more likely to lose everything. The poor's loss of wealth is two to three times greater than that of the non-poor, which puts their livelihoods and their ability to escape poverty at risk (Hallegatte et al 2017). Since the homes of the poor in Mexican cities tend to be more precarious or located in areas more vulnerable to disasters, poor residents are also more likely to lose their lives in a major disaster. Furthermore, the lack of effective preventive measures, regulatory frameworks, and strong

THE POTENTIAL TO GENERATE SOCIAL HOUSING IN CENTRAL AREAS

MÉRIDA, MÉXICO.

	BUSINESS AS USUAL (WITHOUT INCENTIVES)	SCENARIO 1 (WITH INCENTIVES)	SCENARIO 2 (WITH INCENTIVES + FOVIM)
Benefits	None	It allows for the construction of low-income housing *(Vivienda economica)* in the city center	It allows for a higher proportion of low-income housing *(Vivienda economica)* in the city center
			It uses an existing fiduciary fund from the municipality
Density	77 units per hectare	153 units per hectare	153 units per hectare
Housing Units	208	420	420
Total area	17,250 square meters	26,850 square meters	26,475 square meters
% of social housing (USD 15.7K–USD 18.3K)	33%	36%	42%
Uses	Residential	Residential and commercial	Residential and commercial
Parking requirements	1 per housing unit and 1 per every 30 square meter in commercial units	0.5 per housing unit and 1 per every 50 square meter in commercial units	0.5 per housing unit and 1 per every 50 square meter in commercial units
Parking spaces needed	515	267	267
Leveraged returns	2% annual	18% annual	18% annual
	Unfeasible	Feasible	Feasible

safety enforcement makes people more vulnerable to catastrophes. How the Mexican government allocates housing subsidies can thus either increase or decrease the risk of the housing stock.

It is useful to understand how exposed Mexico is to hazards: Almost two-thirds of the country's surface is exposed to significant seismic risk *(Programa Nacional de Protección Civil 2014-2018)*. According to CENAPRED, 35.5% of the population is exposed to flood risk. In States like Tabasco (100%), Colima (92.1%) and Campeche (85.9%) virtually all families are exposed to flood risk. Other States like Aguascalientes and Baja California Sur are exposed to different events including droughts and desertification. Housing actions need to ensure that dwellings are resilient enough to withstand the force of floods and earthquakes that seem to be increasing in both frequency and severity. For example, the earthquakes that took place on 17 and 19 of September 2017 left more than 180,000 housing units partially or completely damaged; more than 60,000 of these damaged houses were located in the state of Oaxaca. The creation of the National Reconstruction Program and the emphasis that the Government has placed on this process is consistent with the fact that reconstruction costs were estimated to amount to more than USD 2.5 billion, with an estimated USD 520 million needed for the reconstruction of private homes *(Senado de la República, 2018)*.

Nonetheless, investing in mitigation –through strengthening and improving existing homes– could pay-off significantly for the Government, while helping the housing authorities achieve their objectives. The reason is simple: mitigation will ensure that disasters do not end up wiping out Government efforts to close the

*North America, Central America and the Caribbean accounted for **83%** of total losses and **93%** of insured losses caused by catastrophic events worldwide in 2017.*

CAPACITY FOR RISK MITIGATION IS LIMITED

2017: **370/2,459 municipalities** (frequently outdated) Risk Atlas.

2017: **329/2,459** have updated construction norms (CENAPRED, 2016).

Current definition of the housing qualitative deficit does not include structural assessments.

*Between 1999 and 2017 disasters caused damages and losses to some **1.7 million** housing units for **USD 8.7 billion**.*

housing gap: disasters registered between 1999 and 2017 caused an estimated USD 8.7 billion in damages and losses to 1.7 million housing units (CENAPRED, 2019). **In Oaxaca alone, it is estimated that small investments in strengthening homes could cut the potential losses by half.**

The Mexican Government that took office in January 2019 redefined the focus of Mexico's housing policies. To respond to the challenge of delivering social inclusion, resilience, and affordable housing, the Government's new priorities are:

- A focus on in-situ new construction and home improvement;
- A focus on the non-affiliated sector and other segments in regions that were previously not reached by the housing programs;
- A focus on housing resilience.

The objectives of the Government's "Social Policies" as defined in the National Development Plan 2019-2024 are to achieve sustainable development and to improve the living conditions for all. In this context, housing is defined as a strategic priority for addressing many other social programs. The Plan defines the Affordable Housing Program, the National Reconstruction Program and the Urban Upgrading Program as the major vehicles through which to reach vulnerable and poor families and those affected by recent disasters, with focus on the territorial, neighborhood and house scales.

Affordable Housing Program *(Programa de Vivienda Social)*

The Right to Adequate Housing as defined by the United Nations Committee on Economic, Social and Cultural Rights underpins the guidelines and operating rules of the Government's Affordable Housing Program. The Government set out the following strategies:

- To facilitate the access of the most vulnerable groups to adequate housing, especially those that have traditionally been excluded from the formal housing market;
- To help meet urban an poverty challenges through the integration of housing policy with other federal programs and projects, with a focus on regions with the highest poverty, groups with the highest vulnerabilities and special attention to population exposed to and affected by hazards and climate related events;
- To strengthen self-construction processes *(Producción Social de Vivienda Asistida)* recognized as the most common practice amongst poor families and communities to incrementally build, improve and expand their dwellings.

The National Reconstruction Program

The earthquakes of September 2017 and February 2018 caused damage and losses to more than 180,000 private homes. Since taking office in December 2018, the Government prioritized the assistance to people whose houses were partially or completely


Puerto Vallarta

OBJECTIVES OF CONAVI'S WORK PROGRAM

(CONAVI, *Programa de Labores*, 2019)

CONAVI's 2019 work plan reflects the priorities to promote resilient and adequate housing for the poor and to redirect efforts towards home improvement and housing reconstruction:

1. Address the housing deficit in particular as it relates to insufficient living space and inadequate housing amongst low-income families
2. Provide home improvement assistance to families that cannot afford new housing
3. Strengthen the sustainability and resilience of people's living environments
4. Promote coordination and co-responsibility amongst federal and state entities and the private sector to address the housing deficit
5. Provide reconstruction assistance and relocation to families affected by disasters

2019 BUDGET ALLOCATION FOR HOUSING PROGRAMS

PROGRAM	BENEFICIARY HOUSEHOLDS	AMOUNT IN USD	AVERAGE SUBSIDY PER HOUSEHOLD IN USD
Urban upgrading program	**20,081**	**115,9 million**	**5,764**
National reconstruction program	**52,311**	**267,5 million**	**5,114**
Reconstruction –Nayarit	**1,310**	**5,6 million**	**4,288**
Affordable housing program	**34,413**	**77.6 million**	**2,255**
TOTAL	**108,115**	**466,6 MILLION**	**4,316**

SOURCE: CONAVI

damaged, particularly in the states of Oaxaca, Chiapas, Puebla and Morelos. The program also provides for the reconstruction of education and health infrastructure, as well as any structures related to "cultural heritage" that were damaged.

The Urban Upgrading Program

The Urban Upgrading Program *(Programa de Mejoramiento Urbano)* focuses on cities with high concentrations of poverty and housing deficits. The Program seeks to attend neglected regions through a combination of policies for upgrading urban housing and housing assistance policies. These include cities with a large indigenous community and cities along the Northern border with high levels of violence and social marginalization. Though many of these cities have significant housing deficits, they have received few housing assistance subsidies in the past.

The budgets allocated to these programs reflect the Government's objective moving towards more targeted support to the most vulnerable groups and their culturally rooted home building practices. More than half of the 2019 budget was allocated to the National Reconstruction Program and to addressing the damages caused by landslides and flooding in Nayarit in 2018; 24% of the budget was allocated to the Urban Upgrading Program and the remaining funds were allocated to the Affordable Housing Program.

However, for these programs to effectively target their beneficiaries and develop adequate and swift responses to Mexico's housing challenge, three gaps must first be closed: (i) an institutional gap, characterized by lack of inter-agency coordination, which hinders effective policy implementation; (ii) a policy gap, epitomized by uncoordinated housing and urban policies, shortcomings in the design of housing subsidies and assistance programs, and lack of support for residential retrofitting; and (iii) a resource gap, referring to the lack of insufficient and outdated information about the housing stock, as well as a lack of standardized instruments for data collection, home improvements, and the provision of flexible and adequate financial services.

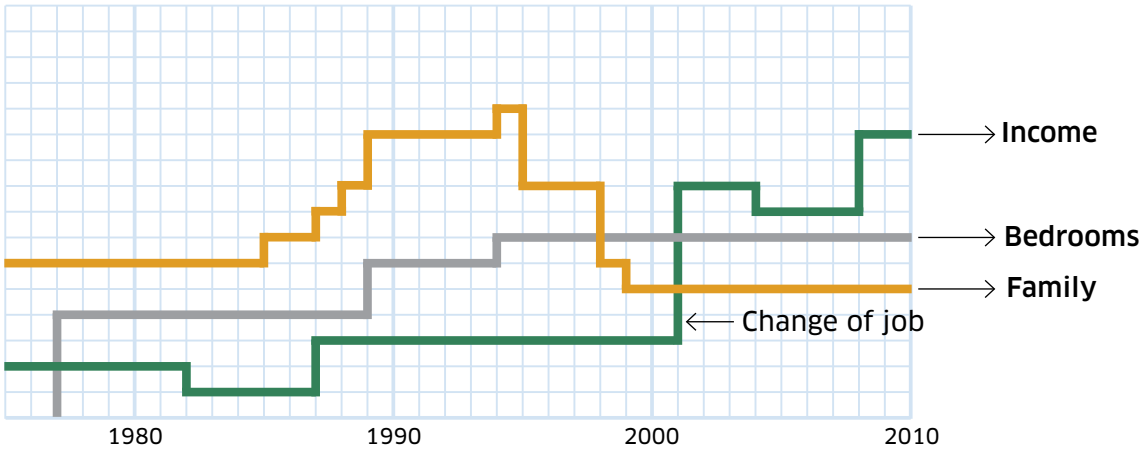
THE GOOD, THE BAD AND THE UGLY OF INCREMENTAL HOUSING

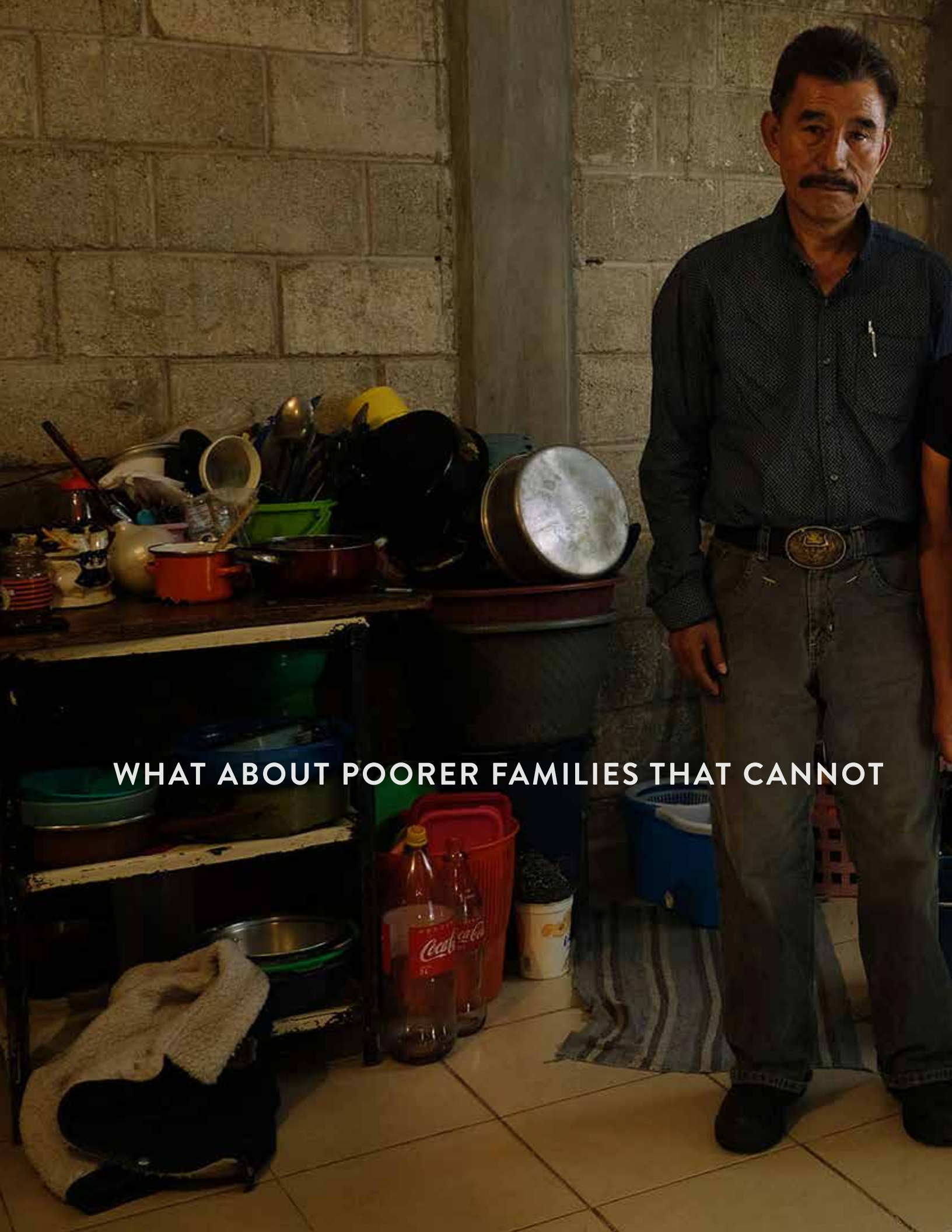
Incremental housing is a step-by-step, staged development starting from an initial small starter core, and growing as needs mandate and resources allow. In the early 1960's, John Turner first coined the term, when he observed the self-made reconstruction of housing after the Arequipa earthquake in Peru. He recognized that people produced the most efficient housing solutions when left to their own devices. Since the 1960s, the process of incremental housing has been growing exponentially in cities with different cultures and socioeconomic backgrounds. In the 1970s, incremental housing projects –then called "sites and services" or "serviced land" projects– were implemented by governments who recognized that many citizens migrating from rural areas could not access formal markets of housing. However, these projects came to a halt around the 1980s (Turner, 1972).

The National Housing Law enacted in 2006 for the first time recognized self-construction as a predominant mode of housing construction in Mexico, particularly amongst low-income communities. When the subsidy program administered by CONAVI was launched in 2007, it allowed consumers to select amongst different housing solutions such as acquisition of new or existing units, improvement or expansion of an existing unit, purchase of a serviced lot, or self- construction rather than only new home purchase. Although housing finance for both self-construction and home improvement steadily increased, the share of financing allocated to this building modality remained small. CONAVI subsidies allocated to self-construction never exceeded 10% of the overall program in any given year (FIVASE, 2012). Starting in 2012, what was originally conceived as a program promoting self-directed home production with the family at the center of the construction process increasingly also devolved into the provision of finished housing units for low-income families. In 2017, 74% of CONAVI subsidies allocated to self-construction were again administered by construction firms that delivered finished houses to beneficiaries (SHF, 2017).

While incremental housing and self-construction suit the needs and financial possibilities of the most vulnerable population, without appropriate technical assistance, it can increase the structural vulnerabilities of their dwellings. Most houses in Mexico are built without the expertise or technical assistance to ensure the resilience of the housing structure at all stages of the construction. Housing units that are incomplete or not well-built are more susceptible to partial or complete collapse during seismic events or other events. For example, in Oaxaca and Chiapas, after the M 8.2 earthquake in 2017, 72% of the housing units that were built with unreinforced masonry experienced partial or total collapse, a construction type that is not accepted by the existing building code in Mexico. In contrast, only 20% of homes made with confined masonry experienced partial or total collapse.

THE INCREMENTAL PROCESS OF HOUSING CONSTRUCTION




WHAT ABOUT POORER FAMILIES THAT CANNOT

AFFORD NEW HOMES AND MORTGAGES?

HOME IMPROVEMENT INTERVENTIONS CAN BE DESIGNED TO STRENGTHEN STRUCTURES AND IMPROVE QUALITY OF LIFE.

2. The Opportunities

The Mexican Government is already equipped with robust institutions capable of providing financial and technical assistance to low-income families to make their homes more resilient. In fact, its years of experience expanding access to formal and affordable housing at a large scale makes Mexico an excellent model for the rest of the region. There is a wealth of lessons and best practices to build upon.

But before the Government can proceed to adjust housing policy to serve the country's neediest population in the most effective and evidence-based way, some critical gaps must be filled in institutions, policies and resources.

GAP IDENTIFICATION

1. Institutional gap

Mexico boasts several public and private organizations already involved in the design, financing and development of social housing. In the last 45 years, more than 120 entities have had a stake in Mexico's housing policy. The federal government is responsible for formulating and conducting the national policy of human settlements, territorial planning and urban development[5] in coordination with federal entities and municipalities, with the participation of the social and private sectors. States and municipalities must apply and adjust their planning processes to the national strategy and administer territorial planning and urban development programs, as well as monitor and evaluate their compliance with the participation of dependencies of the Federal Public Administration and society, and establish comprehensive risk management strategies, promoting and executing actions to prevent and mitigate the risk of human settlements and increase their resilience to natural and anthropogenic events.

To achieve its objectives, the new administration must leverage this experience and expertise. Mexico has been successful at producing standardized, finished housing units at a grand scale. While there is also plenty of experience in the country on home improvement interventions at a smaller scale, these entities are less familiar tailoring their services to individual homeowners, along with the right kind of technical assistance. To close this institutional gap, we recommend that the Government:

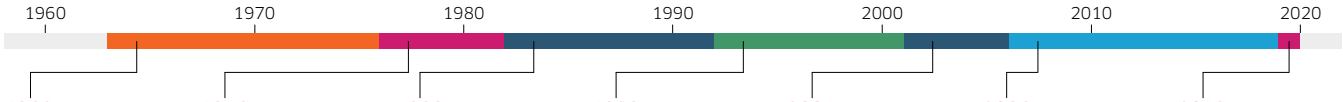
- **Strengthen coordination between institutions.** A wide range of entities are involved in the design and implementation of housing assistance programs in Mexico. But there is too much duplication of efforts and too many bottlenecks. There is an opportunity to revise the responsibilities of these entities to exploit synergies in the selection of target populations and in the effective design of home improvement and retrofit interventions, subsidies and credit schemes. While National Housing Organizations (ONAVIS) such as INFONAVIT, FONHAPO, FOVISSTE and CONAVI, which operate throughout the country are the main source of housing subsidies, assistance programs can be diversified and expanded not only through increases in the provision of subsidies at the federal level, but also through a greater participation of the State Housing Organizations (OREVIS), the financial and microfinance sector and the resources of the population itself[6].

- **The new National Housing Program currently being prepared by SEDATU could play a key role in addressing these issues.** Effective housing policies that prioritize social inclusion and housing resilience build on adequate and updated territorial risk and planning information. To date, housing policy instruments include construction norms, but maps documenting hazards and risks are either incomplete, inexistent or not enforced in most Mexican states and municipalities. CENAPRED must work with State and local governments to update state and municipal risk maps and incorporate them into the National Risk Atlas. The use of this information for investment planning purposes could ensure that the government budget is used to decrease risk and not increase it.

[5] According to the General Law of Human Settlements, Territorial Planning and Urban Development of 2016.

[6] For more information on the actors of the housing sector in Mexico, see Annex 2.

THE INSTITUTIONAL SETTING FOR THE HOUSING SECTOR IN MEXICO



1963
Fondo de Operación y Financiamiento Bancario a la Vivienda **(FOVI)**

1976
Secretaría de Asentamientos Humanos y Obra Pública **(SAHOP)**

1982
Secretaría de Desarrollo Urbano y Ecología **(SEDUE)**

1992
Secretaría de Desarrollo Social **(SEDESOL)**

2001
Comisión Nacional de Fomento a la Vivienda **(CONAFOVI)**

2006
Comisión Nacional de Vivienda **(CONAVI)**

2019
Secretaría Desarrollo Agrario, Territorial y Urbano **(SEDATU)**

NATIONAL HOUSING PROGRAM

1979
Programa Nacional de Vivienda

1980
Programa Nacional de Desarrollo Urbano y Vivienda 1984-1988

1990
Programa Nacional de Vivienda 1990-1994 and *Programa Sectorial de Vivienda 1995-2000*

2000
Programa Sectorial de Vivienda 2001-2006 and *Programa Nacional de Vivienda 2007-2012*

2010
Programa Nacional de Vivienda 2014-2018

2019
**Programa Nacional de Vivienda 2020-2024*

THE ROLE OF THE STATE IN THE HOUSING SECTOR

1972-1992
Market Maker: **INFONAVIT** starts both building and financing housing.

1985-?
Social housing provision by **FONHAPO**. **BANOBRAS** in charge of the construction.

1993-2000
INFONAVIT's social mortgage. **INFONAVIT** abandons the construction business.

2006-NOW
Promotor of better located housing.

2001-2012
A force to reduce the housing deficit. **INFONAVIT** as a banker.

2013-2018
Social Changer. **INFONAVIT** as a financial institution with a social purpose.

2019
Elimination of public trusts **FONHAPO**.

2018-2019
The Citizen at the center of all housing policies and programs.

THE POLICY INSTRUMENTS FOR THE HOUSING SECTOR IN MEXICO

1981-2006

Implementation of **FONAHPO**'s credit program.

1989-1994

Home Improvement Actions by the Solidarity Program from **SEDEU-SEDESOL**.

1992

Creation of the Special Program for the Promotion and Deregulation of the Housing Sector **(PEFDV).**

1992

100 Cities Program from **SEDESOL** that included housing subsidies.

1995

Total Solution Program from **FOVISSTE**, created after the 1994 economic crisis.

1995-2000

Implementation of the National Housing Program **(PNV)**.

2000

FONHAPO stops giving loans.

2000

Start of the *Piso Firme* Program from **SEDESOL**.

2001

Housing Sectoral Program 2001-2006 **CONAFOVI-CONAVI**.

2001

Implementation of the *Tu Casa* Program from **CONAFOVI**.

2001-2006

Implementation of the National Housing Program **(PNV)**.

2001

INFONAVIT's Support Program that introduces mortgage guarantees to loans generated by commercial banks.

2002

Opportunities Program from **SEDESOL**, focused on home improvement and acquisition for vulnerable groups.

2003

Implementation of **INFONAVIT**'s credit program for low-income housing.

2003

Implementation of Program "Savings, Subsidy and Loan" for Incremental Housing **(VIVAH)**.

2003

Military Housing Fund **(FOVIMI)** recognized by **ISSFAM**.

2003

Creation of Habitat –**SEDATU** Program.

2005

FOVISSSTE starts cofinancing operations with banks.

2006

Implementation of the Rural Housing Program –**FONHAPO.**

2006

SEDESOL's subsidies started to be used for new housing.

2007-2008

CONAVI starts 4 programs (**DUIs**, **DUIs**, building code, **NAMAS**, **NAMAS**, sustainability).

2007

Creation of **INFONAVIT**'s Green Mortgage Program, *Vida Integral* and Qualitative Evaluation of Housing **(ECUVE)**.

2007-2015

Implementation of the Federal Subsidy and Financing Schem for housing.

2007-2012

Reengineering of the Programs for Rural Housing and Savings, Subsidy and Credit for the Incremental Housing –*Tu Casa*.

2008

INFONAVIT-FOVISSSTE start giving loans to married couples.

2008-2012

Implementation of the Program for Federal Subsidies by **CONAVI**.

2008-2012

Implementation of the Program for the Modernization of Property Registry and its linkage with the Cadaster –**SHF**.

2008

Program for the Support and Regularization of Informal Settlements **(PASPRAH)**.

2009

FOVISSSTE starts issuing certificates that can be traded in the Stock Exchange.

2009

Cretion of the Program *EcoCasa* from the **SHF**.

2009-2010

SHF expands its scope and includes home improvement and self-construction with technical assistance in its portfolio.

2009-NOW

SHF responds to mortgage crisis, buys assets from **SOFOLES** and **SOFOMES**.

2012-2017

MEJORAVIT from **INFONAVIT** starts operating.

2013

Creation of the Program for Decent Housing.

2013

Creation of the Program for Rural Housing and Program for the Promotion of Rural Consolidation.

2013

Creation of **CONAVI**'s **RENARET**.

2014

Publication of the National Urban Development Program 2014-2018 that creates the "urban perimeters".

2014

SEDATU implements the Program for the Resettlement of People living in hazard areas **(REPZOR)**.

2014-2018

Creation of the Program for a Sustainable Housing Development.

2014

Beginning of the Program for the Consolutation of Urban Land Reserves by **SEDATU**.

2014

The Opportunities Program is renamed and becomes **PROSPERA**. It includes incentives and housing financing support for families living in poverty.

2015

Pilot Program **ARRENDAVIT** from **INFONAVIT** to recover the housing units that were occupied before 2015.

2016

SEDATU merge the **POTER** and **S237** and creates the "Program for Risk Prevention".

2016-2018

Implementation of the Program for Access to Financing for Housing.

2016

Implementation of the Program for Housing Support.

2016

CONAVI creates the National Registry for Territorial Reserves **(RENARET)**.

2017

Creation of the Programs for Credit and Annual Financing approved by the Executive Commission from **FOVISSSTE**, the Total Solution Program for to expedite the payment of debts and transfer of properties and the Program for Housing Reconstruction to respond to the 2017 earthquakes.

2016-2018

SEDATU improves the Program for Risk Prevention.

2018-NOW

Program for Shared Responsibility continues.

2018-NOW

Implementation of the Program for the develution of resources from **INFONAVIT**'s Savings Fund 72-92 to retirees from the **IMSS**.

2018-NOW

Program for Indigenous Infrastructure that provides housing to indigenous households.

2019

MEJORAVIT continues.

2019

ARRENDAVIT ends.

2019

Housing Insurance Program by **SHF** continues.

2019

Green Mortgage Program by **SHF** continues.

2019

Start of the Program for the Regularization of Informal Settlements **(PRAH)** by **INSUS**.

2019

RENARET continues through the Program for Social Housing 2019.

- **Build the capacity of state entities at the federal, state and municipal level in the housing and planning sector.** There is an opportunity to strengthen coordination between the federal and municipal levels so that municipalities have the capacity to implement housing and planning programs as effectively as possible. This will also empower municipalities in several ways: to make more efficient use of intraurban land; promote land value capture and initiate new housing developments with private sector partners; promote normative changes as required; increase their tax base; and promote more sustainable urban development patterns.

- **Strengthen the ecosystem for providing specialized technical assistance and tailored housing assistance.** One place to start is by improving the mechanisms by which public and private organizations can coordinate their efforts to provide specialized technical assistance to guide and accompany home improvement and self-construction efforts. OEOs (Works Executing Entity) and AOs (Operation Administrators) could be used more frequently as certified intermediaries to train and develop intermediary advisors, institutionalize and professionalize technical assistance schemes through home improvement and retrofit guidelines and standardized plans, while developing a long-term presence in the community that will help generate confidence among homeowners.

2. Policy gap

The Government is now formulating the details of new housing programs that will guide its efforts in the coming years. Here are some recommendations for measures that we believe will help realize the new administration's vision:

- **Improve the use of granular data of the housing sector.** Sound diagnostics must be institutionalized as the basis for designing and implementing all aspects of the housing programs, including:

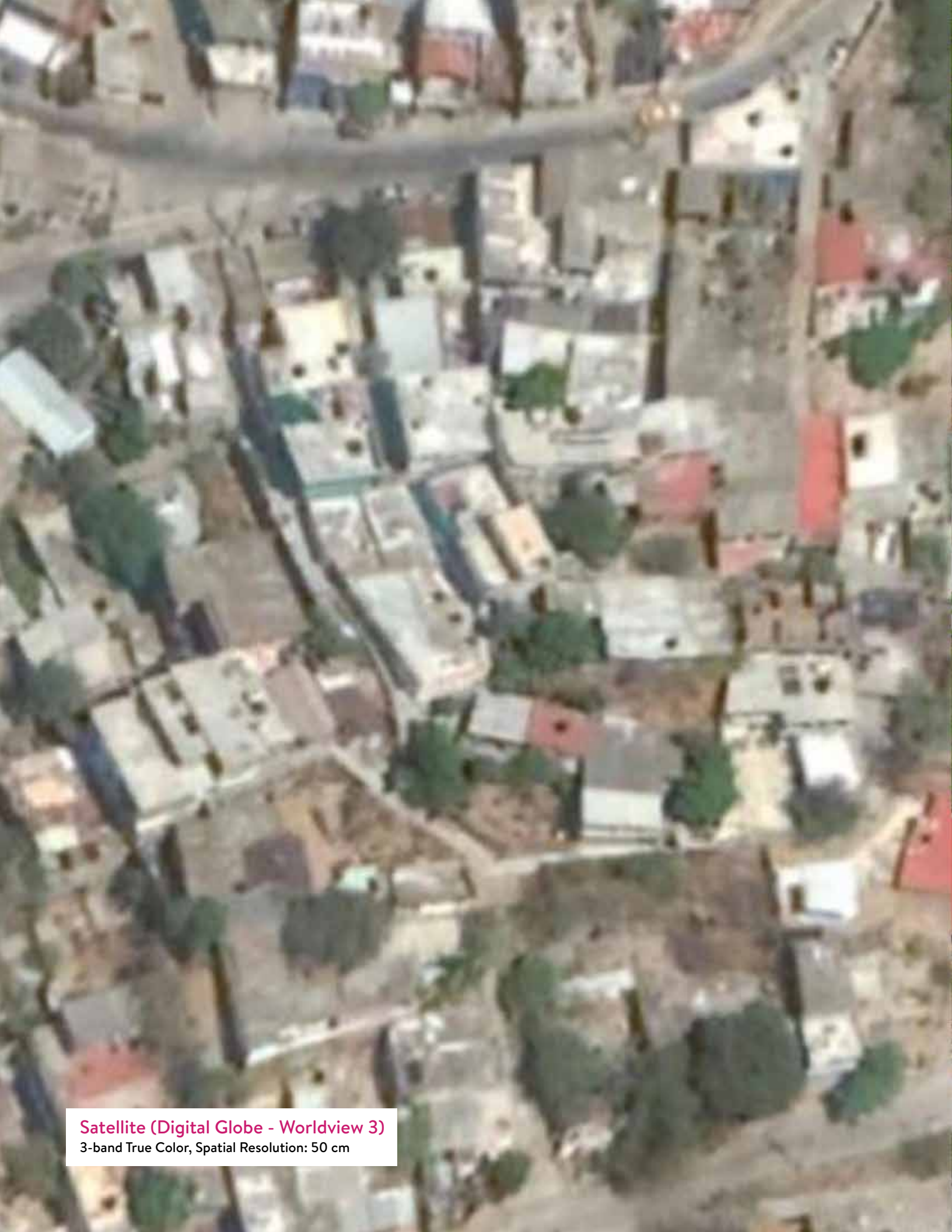
  - **For the Affordable Housing Program,** it would be critical to identify the characteristics of the housing stock to inform decisions about the allocation of resources through different instruments and target audiences, with a focus on the most vulnerable. A sound diagnostic could also help the country move from discussing the size of the housing gap (while some estimate it to be 9 million units, other equally credible sources estimate it to be 14 million) to evaluating different options to close it.
  - **For the National Reconstruction Program,** a focus not only on damaged properties but also undamaged houses that present building deficiencies –with the objective in mind "to build better before," would help significantly reduce the future estimated losses the country faces in case of disasters.
  - **For the Urban Upgrading Program,** more granular data could be of great benefit achieve the Government's objective of helping the poorest and most vulnerable population who are not eligible for support under the other programs and who need not only access to better homes but also integration to society through the access to basic services, jobs, education and health services and other amenities.

- **Increase housing resilience by integrating structural strengthening as part of home improvement investments.** The Government, for example, could use the Affordable Housing Program to pair structural retrofits with home improvement measures as a critical step to achieving a resilient housing assistance framework in disaster-prone areas. To effectively increase housing resilience, the Government needs to complement home improvement measures with targeted actions to reduce housing vulnerability. This includes institutionalizing vulnerability assessments and identifying a set of retrofitting standard options that could complement existing home improvement programs (see Annex 1), as well as streamlining administrative procedures to obtain building permits for retrofit interventions and/or to regularize properties.

- **Support self-construction.** It is well-known that, most Mexican families opt for building their homes themselves, without technical assistance, rather than buying a new or existing unit. These self-built houses make up a significant share of the qualitative deficit of Mexico's housing stock. The Affordable Housing Program could benefit families by providing housing assistance and subsidies specifically designed to support home improvement and do-it-yourself construction.

FOR EVERY DOLLAR INVESTED ON INFRASTRUCTURE STRENGTHENING BEFORE, IT'S BEEN PROVEN THAT AT LEAST 4 DOLLARS ARE SAVED IN RECONSTRUCTION EFFORTS LATER.

- **Prioritize geographical areas with the largest housing deficits.** Today, the Mexican states with the highest housing deficit are Chiapas, Oaxaca, Guerrero, Veracruz and Campeche (CONAVI 2015). Over the last 12 years, however, these same states did not receive a comparable share of overall housing finance. In fact, states with low housing deficits received higher amounts of housing finance (e.g. Nuevo León). A larger budget allocation to states with higher housing gaps could also help develop the capacity of the providers to operate in the targeted market segments. However, it is advisable to use a gradual and programmatic approach that allows these changes to be properly planned, so that they do not suspend or stop serving needy populations regardless of the size of the deficit in the state in which they live.



Satellite (Digital Globe - Worldview 3)
3-band True Color, Spatial Resolution: 50 cm

Drone (Ebee —3D S.O.D.A)
3-Band, True Color, Spatial Resolution: 3.65 cm

- **Strategically position subsidies and incentives to promote energy efficiency and renewable energy.** Between 2016-2018, CONAVI administered a program to subsidize investments that increase energy efficiency or renewable energy as components of the Affordable Housing Program. Based on this experience and on comprehensive technical and economic analysis of the sector, the Government could design new instruments that can be scaled up to contribute to more efficient, affordable and sustainable energy consumption patterns of target households. The experience of other entities like INFONAVIT and SHF on this topic could inform CONAVI's effort.

- **Coordinate urban and housing policies with urban upgrading and other programs.** There are synergies in information collection, communication, civil society participation, etc. that can be leveraged to enhance the benefits of resilience, home improvement and other programs to improve urban housing, such as upgrading neighborhoods, land titling, resettlement, and infrastructure for basic services. Coordination in the planning and implementation stages of such activities is key to achieve better results and avoid overlaps and inefficiencies. For example, an effective coordination of the Affordable Housing and Urban Improvement Programs can enhance the goals of both programs.

3. Resource gap

When designing a housing program to meet the needs of the poorest segments of the population, the first requirement is a comprehensive diagnosis of the state of the housing sector, which involves: (i) a consistent methodology to measure the housing deficit; (ii) a transparent and accessible tracking and monitoring system of all housing interventions; and (iii) an updated assessment of Mexico's housing stock that includes a housing vulnerability assessment. To ensure the needs of the poorest are being targeted, the following activities should be performed:

- **Review Mexico's operational definitions for the housing sector.** This includes revising the official methodology, definition and measurement of the housing deficit, while updating and adding to databases such as the Single Housing Registry (RUV).

- **Develop a robust and simple methodology to characterize and assess the vulnerability of the housing stock, based on a consensus among national experts.** Rapid and effective housing assessments consist of three steps:

  - Identify houses where risk cannot be reduced, thus ruling out retrofitting. The minority of homes located in areas where risks cannot be mitigated, including those in flood plains or landslide prone slopes, must be declared uninhabitable and the residents resettled.
  - Identify houses with structural risks that can be repaired. Housing engineers can visually inspect rows of substandard housing units and rapidly identify the common structural inadequacies.
  - Identify –with geospatial tools– patterns of structural vulnerability that are common and can be addressed with standardized and scalable retrofitting interventions designed by engineers. The large majority of housing units in Mexico have been built with safe materials and common construction methods. Addressing any remaining structural vulnerabilities/deficits can be done at relatively low-cost, transforming a deadly structure into one strong enough to resist future stress. Both the Urban Improvement Program and the Reconstruction Program can benefit from a geospatial information system that informs decisions about home and urban improvements, as well as about reconstruction, resettlement and formalization.

- **Design technically and economically viable home improvement instruments.** Bringing existing houses up to a decent standard of safety is not only a more efficient way to deploy limited government funds but an effective strategy for saving lives. The Government program can simplify and improve the process for designing and implementing home improvement subsidies by:

  - Developing standardized home improvement options, where possible.
  - Incentivizing the development of private sector solutions.
  - Leveraging private resources, such as household investments and home improvement microfinance markets.

- **Promote financial inclusion by designing financial instruments for savings, credit and insurance that suit the needs of Mexico's different population segments.** Access to quality financial services, such savings accounts, credit schemes and home insurance, can soften the impact of catastrophic events –even prevent people from falling into poverty or becoming poorer. In Mexico, according to the Global Findex (2018), among the poorest 40%, only 5.2% borrowed from a financial institution or used a credit card in 2017; more than 75% of them reported that they couldn't come up with funds to deal with an unforeseen emergency[7]. Mexico's housing programs should consider the use of multiple financial instruments to provide flexibility, such as: long-term low-interest-rate loans, municipal or national grants, compensation through property taxes, more favorable financing terms for safer buildings, some pass-through costs, and reduced property insurance.

AREA OF INTEREST

METHODOLOGY DEVELOPMENT AND CASE STUDY

Mexico has started to develop a policy framework that aims at redirecting its housing policies to include the poor and most vulnerable. An important, cost-effective element of this change consists in rebalancing its programs not only to produce new housing but also to increase the resilience of existing housing. Therein lies another challenge: To improve existing housing belonging to the poor will require Government to operate in areas that are not only more exposed to different hazards but also for which data is scarce, outdated or non-existent.

To explore ways of adding value to the authorities' efforts, CONAVI and the Bank Team agreed on an area of interest and applied a methodology developed by the Global Program for Resilient Housing to capture detailed information about the housing stock and to identify opportunities for strengthening existing structures and other improvements. This methodology was already successfully applied in a range of other countries, including:

- **In Colombia,** assistance is being provided to the government for the design and implementation of its recently launched housing improvement subsidy "Casa Digna, Vida Digna" (Dignified House, Dignified Life).
- **In Guatemala,** buildings at risk of collapse in case of an earthquake were mapped and identified.
- **In Indonesia**, the government is working on including resilience as a central element of its housing improvement program, one of the largest in the world.
- **In Peru,** technical assistance was provided for the realization of automated real estate valuations, the improvement of local tax collection and the identification of structural vulnerabilities.
- **In St. Lucia,** roof damage caused to homes by Category 5 hurricanes was assessed.
- **In Sint Maarten,** the government is working on estimating the costs of scaling up its resilient housing program.

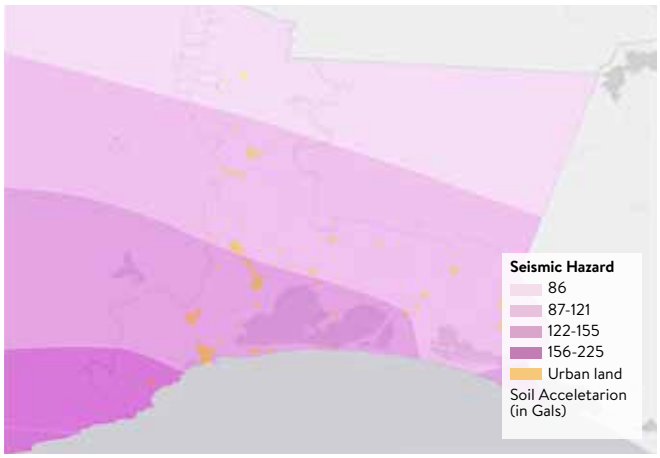
The selected area was Oaxaca's Istmo de Tehuantepec Region because of its long history of seismic activity. In 2017, an 8.2 M earthquake struck southern Mexico. Damages were concentrated in the states of Chiapas and Oaxaca, with the epicenter in Pijijapan, Chiapas. Only twelve days later, another M 7.0 earthquake struck Puebla and Morelos, shaking the center of the country. A total of 5,735 seismic events were recorded in Mexico for the month of September, damaging a total of 186,526 houses. The hardest hit state was Oaxaca –with damage to 80,310 private houses[8]. Then came its neighbors, Chiapas with 46,546 damaged houses and Puebla with 28,343.

In the aftermath of those earthquakes, structural engineers sent to the field found that most structures built after 1985 performed well. Why? After the massive M 8.0 earthquake in Mexico City in 1985, authorities began to pay more attention to structural vulnerabilities and pushed for adopting advanced construction techniques that would keep buildings from crumbling during earthquakes. In the state of Oaxaca, for example, and more specifically in the Istmo de Tehuantepec Region, the housing stock consists of predominantly one –and two– story masonry buildings that fare relatively well

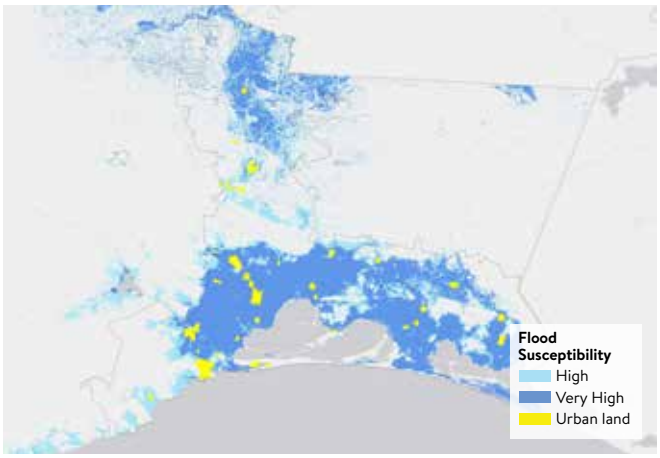
[7] Defined as 1/20 of the GNI per capita in local currency.

[8] Includes damages of the earthquake in February 2018.

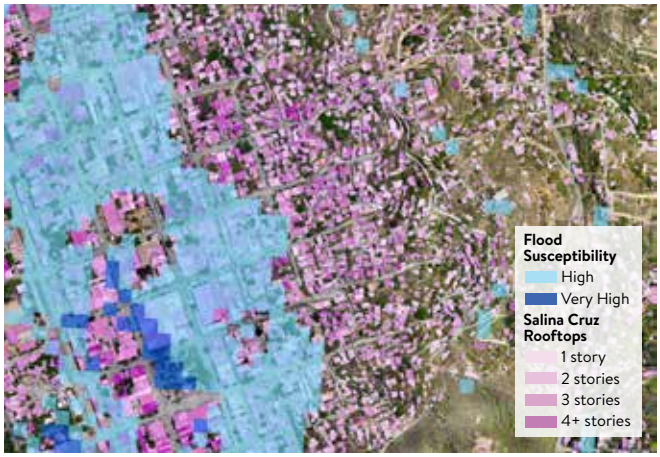
EARTHQUAKE HAZARD



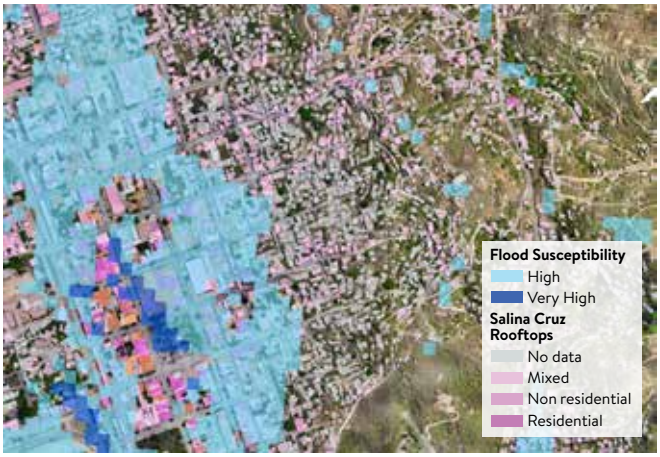
FLOOD HAZARD



FLOOD VULNERABILITY



FLOOD VULNERABILITY



during earthquakes –if they are well-built and located on safe terrain. Such structures are therefore good candidates for low-cost and life-saving retrofitting, along with investments that improve the quality of life of their inhabitants.

The team's first conclusion was that for SEDATU and CONAVI to succeed with the type of housing policies they are promoting, they needed data on the housing stock at the right scale. Their policies and goals of serving the poorest segments of the population are aimed at families who live in homes for which good data is not usually available. The recommended approach for better identifying these housing structures, therefore, must begin from high above and then zoom down to a more detailed picture of the housing and its terrain. Hazard maps are useful tools for the identification of flood, seismic, tsunami, and landslide events across a large area. Leveraging satellite imagery, topographic information and past events, they reveal where the hazard exposure is highest. By overlaying these hazard layers with population information, the Government can get a general idea of the intensity and likelihood of hazards affecting cities. For example, it is possible to compare the distribution of the urban population in Istmo de Tehuantepec Region with the intensity of earthquakes and flooding hazards.

But hazard maps alone are not enough to help the Government prioritize the allocation of home improvement subsidies that will increase housing resilience. More granular data is needed. And we can now get that, more quickly and affordably. Using the advanced technology of drones, 360-degree street cameras, and machine learning algorithms you can now screen houses –remotely– for vulnerabilities generated due to the use of substandard materials or inadequate construction techniques.

SEDATU and CONAVI need tools that will identify housing vulnerabilities at every level –national, neighborhood and individual housing unit.

During this ASA, the World Bank Team gathered data in the Istmo de Tehuantepec Region and applied a 3-step methodology to inform programs aimed at improving living conditions while increasing housing resilience.

ADVANTAGES USING DRONES IN NEIGHBORHOOD LEVEL ANALYSIS

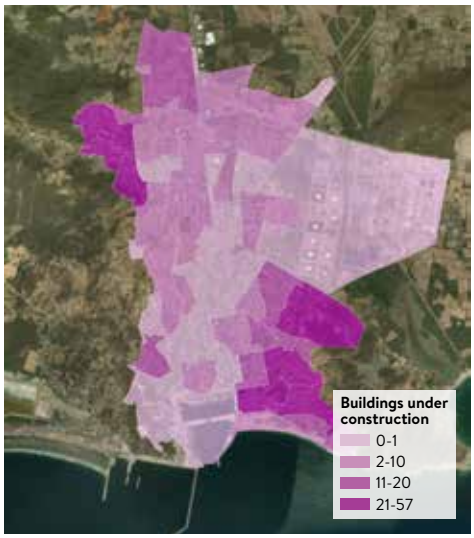
1. **A geospatial housing needs assessment tool** that incorporates disaster risk information to better prioritize and target subsidies;
2. **A multi-stage and flexible subsidy design** that is conducive to incremental and resilient construction and enables families access multiple subsidies over time. These subsidies need to include a condition and/or incentive to complete the necessary structural reinforcements before any other improvement and a strong linkage with microloans to allow households to pool resources to combine home improvements with structural reinforcements in a single intervention.
3. **Specialized technical assistance** capable of delivering standardized and affordable technical solutions to lower the cost of engaging with citizens, while encouraging private sector investments in construction, credit and insurance markets, including the identification of standardized solutions, tools for calculating works' budgets and identification of reliable suppliers.

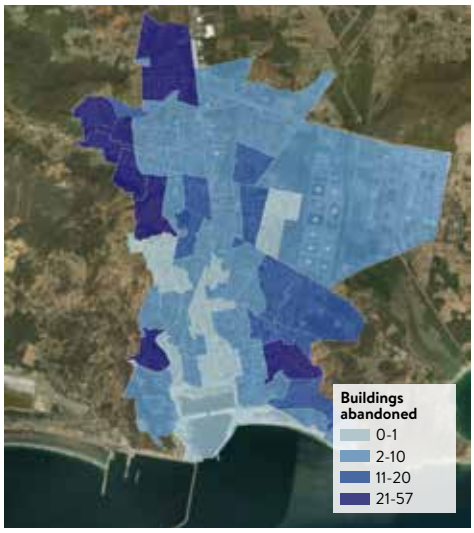
A geospatial housing needs assessment tool

CONAVI and SEDATU need to adopt a methodology that combines well-designed policy schemes with disruptive technology for targeting and prioritizing areas that should receive home improvement subsidies and/or neighborhood upgrading. Operating at three levels, the approach will seek to save lives, protect assets and shield economies.

1. National level: The Government of Mexico can use this methodology to identify municipalities with a high concentration of low-income urban households that could greatly benefit from risk reduction investments. Using national scale geospatial hazard layers, combined with population density and socio-economic information would make it easier to

AREAS OF CHANGE/TRANSITION
Salina Cruz





prioritize municipalities with a high percentage of their population living in hazard prone land. For example, if the urban center of a municipality exists mainly in a flood plain or has a long history of seismic activity, that municipality should be a candidate for substantial funding. In Oaxaca's Istmo de Tehuantepec Region, the team began by compiling an inventory of national level spatial data layers: landcover, census data, hazard risk (generated by Mexico's Comprehensive Risk Management Strategy (EGIR) in 2014), and infrastructure locations. With a complete package of layers, data dictionaries and metadata in hand, it is possible to determine the scale and distribution of the multiple risks a region faces. While this database provides a strong baseline for assessing housing needs at the regional level, it lacks the detailed spatial resolution to inform decision makers about which homes should receive a subsidy first, or which are good candidates for a specific intervention.

2. Neighborhood level: Geospatial data from drones and satellite can be analyzed to ensure interventions are reaching clusters of vulnerable homes. For this level of analysis, drones or high-resolution satellite imagery is needed. Satellite imagery allows for the detection of construction in risky land, by revealing building location (count and perimeter of rooftop), roads (length and width) and topography (slope of the terrain). Overlaying this information with hazard layers reveals neighborhoods that are prone to flooding (located in low lying land near rivers), or areas that are too steep for building. In addition, information about the neighborhood's general connectivity and building footprint density can be calculated. However, for more in-depth analysis, such as the true size of the homes (calculations including height) or the quality of public infrastructure –drone images are required. Drone imagery could provide policymakers with the type of detailed information they need to improve the effectiveness of their policies and programs.

Such data can also reveal neighborhood growth dynamics by showing areas with high concentration of homes that are under construction or abandoned.

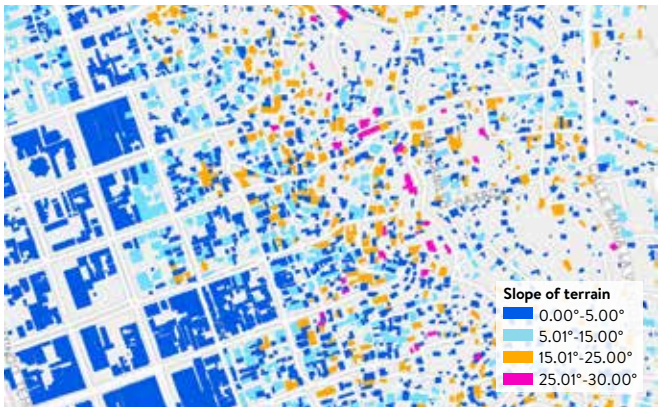
3. Housing unit level. Leveraging drone and street view imagery provides information about not only the location, dimension, quality, and material of each building but also information on the front of the building (use, wall material, features). All the attributes that are extracted when machine learning is applied to street view and drone images can be presented in a Housing Passport.

With the rich household level database derived from street view and drone imagery, home improvement programs can better target certain types of at-risk homes. For example, if CONAVI were interested in allocating housing subsidies, such imagery would help them quickly rule out homes built along earthquake faults or on the edge of cliffs as too risky; but not homes in areas with medium or high seismic risk that have been built with good quality materials and reasonable construction techniques. In Salina Cruz, 2% (2,211) of the buildings (98% residential) were found to have been built on ground with a slope greater than 15%. With this data, homes that have been constructed on dangerous slopes on the hillsides near the city center can be located and quantified. The structural integrity of such homes should be a priority in any retrofitting program. Homes constructed on solid ground but adjacent to a road that frequently floods due to poor drainage should be prioritized for mitigation investments. It is in these areas that public investments in home improvement subsidies can be combined with disaster risk management best practices to deliver the maximum impact.

In addition to improving disaster risk manage practices, a detailed database of the housing stock will help Mexico prioritize scarce engineering personnel by optimizing routes and making the best use of their time by sending them to assess those homes that need more detailed assessments with data and images about the structures in hand. For example, in Salina Cruz, when the database is filtered to show buildings that are potentially soft story (at least two stories high and with large first floor openings), out of an estimate of the 15,261 structures that were captured on street view, 904 of

ROOF QUALITY ASSESMENT

IDENTIFICATION OF SUITABLE LAND



IDENTIFICATION OF POTENTIAL SOFT-STORIES

THE POSITIVE IMPACT OF RETROFITTING

LESSONS FROM MEXICO'S HOME IMPROVEMENT PROGRAMS

Mexico's most popular home improvement programs focused on targeted interventions to reinforce floors, walls and ceilings, install bathrooms or add additional living space. One of the most successful home improvement programs was *Piso Firme,* administered by SEDESOL to replace mud floors. Between 2006 and 2013, SEDESOL was able to improve 3.1 million homes in this way, thus reducing Mexico's qualitative deficit significantly. Although this intervention was low-cost and simple (it could be completed by the homeowners), it had a huge impact in terms of improving health outcomes in children and adults.

In contrast, FONHAPO's *Cuarto Adicional*, which sought to address problems of overcrowding by adding additional living space was not as successful. Although the program reached scale and upgraded almost half a million homes in 5 years, independent evaluations show that in most cases, the additional room was not always used as intended; often times it resulted in further overcrowding, as entire families occupied the newly won space. However, this type of intervention is still very much needed; its operational delivery model should be improved.

FONHAPO's experience with *Cuarto Adicional* also, has illustrated that the verification of the progress, completion, maintenance and use of the investments is critical to the program's success. To that end, FONHAPO, SEDESOL and CONAVI developed strong monitoring and information systems for registering and tracking home improvement measures, which, in turn, facilitated the verification of each intervention. The Housing Registry (RUV) administered by CONAVI tracks progress of construction alongside other relevant data on the national housing supply, location and housing quality and has become an important source of information to improve decision making of both public and private actors involved in housing provision.

BUILDING PASSPORT

LOCATION

ATTRIBUTES

ROOF MATERIAL	Concrete-plastered
ROOF CONDITION	Good
AREA	650.11 m²
HEIGHT	11.20 m
VOLUME	1,601 m³
TERRAIN SLOPE	2,5°
USE	Commercial
WINDOWS	5
DOORS	2
GARAGE	1
WALL MATERIAL	Concrete
WALL CONDITION	Good
SEGURITY	No
COMPLETE	Yes

RISK

VALUE

ANALYSIS

them had more than 1 garage and were at least two stories high. This could indicate the presence of soft-story. Such a map would guide engineers to visit these homes first, or, depending on resources, require a field visit only if the 'potential' soft story building is requesting a home improvement subsidy. Upon arrival, engineers would have pictures and basic statistics about the home and its neighborhood. Such a system would link all information to a precise location and allow for the tracking of all beneficiaries through a spatial referenced household database. Authorities could later return to the homes to ensure after the works have been completed and ensure that technical standards have been met.

A multi-stage and flexible subsidy design

The main federal entities to finance home improvement in Mexico over the past decades have achieved a good balance in terms of coverage. Mexico's Social Development Ministry (SEDESOL) and the Affordable Housing Fund (FONHAPO) had a clear mandate to reach the poorest segments and those that are excluded from the formal housing sector[9]. The home improvement subsidies and credit from INFONAVIT and CONAVI targeted low-income but affiliated workers with access to mortgage loans. Most programs were focused on improving finishes, fixing roofs and adding habitable space. However, in terms of the quality of the interventions and their resilience, the results of these programs have been mixed.

To calibrate the costs and potential savings of interventions aimed at reinforcing the housing stock against different catastrophic events, it is necessary to conduct an assessment of potential losses. For this task, the geographical analysis of hazard and exposure is useful but limited since it only presents information on exposed assets but not about the range of possible losses or the probability of their occurrence. For the Istmo de Tehuantepec, catastrophe models were developed to better understand the probability of observing large losses.

This analysis consisted of performing three major processes:

a. Threat modeling carried out through simulation of individual scenarios, assigning each one a frequency of occurrence;
b. Vulnerability modeling in terms of average percentage of damage depending on the intensity of the threat and;
c. Risk estimation in terms of expected losses through the construction of a probabilistic model.

To calculate the average and extreme losses, a simulation process of each of the scenarios considered was carried out to probabilistically integrate a curve with the results obtained using the frequency of occurrence in each scenario as weight factors.

Through this analysis it was found that seismic risk was the most relevant in the Istmo de Tehuantepec Region.

[9] SEDESOL's housing-related programs were transferred to SEDATU in 2013 and FONHAPO's programs will be implemented by CONAVI from 2020.

Different simulations were performed with the main construction variables (number of stories, wall materials, type of roofs, etc.), resulting in no major changes in the composition of the portfolio versus total risk contribution, which suggests that construction technique instead of building materials presents the greatest contribution to vulnerability. One of the most important findings was the behavior of unconfined masonry: while these structures represented 18% of probable losses, with an earthquake, they increased by almost 3 times to 56% of the total portfolio risk. To verify this finding, a simulation was performed assuming that there was a massive retrofit for 18% of homes in the study area, which revealed that estimated losses would decrease by half, saving almost 1,400 million pesos –only due to the conversion of unconfined masonry homes to confined masonry ones. Thus, the value proposition of home improvement programs is two-fold: for housing authorities, they deliver better quality of life for the most vulnerable segments of the population; for economic and finance authorities, they can reduce significantly the contingent liability that is concentrated in the housing sector in the event of a disaster.

Specialized technical assistance

While incremental housing and self-directed construction respond to the needs and financial means of the most vulnerable population, unless accompanied by technical assistance to ensure the resilience of the intervention, they could lead to an allocation of housing subsidies that increases the risk of the housing stock instead of decreasing it. Unfinished housing units collapse during seismic events or other disasters. This highlights the need to integrate structural retrofit in standard home improvement processes that focus on improving the family's living conditions.

Tailored home improvement measures and structural modifications need to be accompanied by specialized technical assistance, while putting families at the center of the decision-making and execution processes. CONAVI was particularly successful in developing the program *Esta es tu casa* combining specialized technical assistance with self-directed construction processes. The strength of this approach was that it placed the family at the center of the process as each home improvement measure was designed and implemented by the beneficiary. This was in stark contrast to the traditional housing assistance models in Mexico where executing entities and private developers would deliver the finished housing unit to the beneficiary.

CONAVI has collaborated with a range of entities, including non-profit organizations, microfinance institutions and social cooperatives, to generate a niche market for the provision of technical assistance to beneficiary families. These organizations needed to be accredited to provide these services. The program administered by CONAVI was very flexible at the initial stages and a substantial dynamism and diversity developed in the sector in terms of who was able to provide technical assistance and under what terms, including non-profit organizations dedicated to the provision of technical assistance, and cooperatives and microfinance institutions that hired architects and engineers to provide technical assistance in-house.

In order to design tailored technical assistance schemes, it is necessary to know the different retrofit needs of the housing stock. In the Istmo de Tehuantepec, engineers visited the study area to evaluate in-situ the conditions of the housing stock and assess the feasibility of structural strengthening. In two weeks, a team of three engineers performed both rapid assessments in more than 100 homes and in-depth assessments of some 40 homes. Many of the homes visited had been affected by the September 2017 seismic events, and therefore provided valuable insights into local housing vulnerabilities.

Following the field visits the team developed an inventory of the housing stock that included the following information: (i) location criteria; (ii) construction characteristics; (iii) estimated needs for reconstruction and retrofit.

The predominant housing typology in the region is one and two stories masonry construction. This masonry is mostly composed of confined, or partially confined, solid concrete block walls. Confined hollow concrete block, and unreinforced fired clay brick walls are also present. Other housing typologies exist as well, in much lower numbers, such as adobe and other earth construction like bahareque, and temporary shelters built out of lightweight improvised materials. The analysis identified the adobe and lightweight material houses as the ones that suffered a higher level of damage in the earthquake. However, several confined masonry homes presented structural and seismic deficiencies, such as:

- Incomplete confinement connections, mostly missing vertical reinforcement of window and door openings.
- Poorly framed timber structures in roofs, with loose heavy clay tiles.
- Construction quality issues, such as concrete cover of reinforcement in slabs, promoting rebar corrosion, and low masonry unit strength.
- Configuration issues. As open fronts, lack of cross walls in interior spaces, missing door and window concrete lintels, or sills.

A full report of these vulnerabilities and solutions was also completed. The team used the menu of retrofitting solutions provided by the engineers and match them with the household level typology derived from the drones and street view images. For example, all homes built with concrete blocks and a maximum of two stories that present building defects can be considered as candidates for reinforcement consisting of simple measures, such as the installation of missing confinements in the wall openings, including windowsills, jambs and lintels, new walls and fillings, strengthening of selected walls with plaster, and installation of missing confinement columns. The initial estimate of the costs of a typical modification of an undamaged masonry house is USD 30 per m^2, a price tag significantly lower than the reconstruction one (USD 300 per m^2). This number, when combined with the rooftop footprint derived from the drone, provides the government with an essential ingredient in the design of a housing resilients program.

AVERAGE COSTS FOR RETROFIT* BY STRUCTURAL SEISMIC DEFICIENCY

TYPICAL CONFINED MASONRY HOUSE		
TYPE OF INTERVENTION	AVERAGE COST FOR 70 M^2 HOUSE USD	AVERAGE COST USD/M^2
Type 1: New Build (excludes demolition, plot, and temporary housing)	**21,000**	**300**
Type 2: Basic Retrofit (excludes repair of EQ damages and roof replacement)	**2,100**	**30**
-Installing missing confinement at wall openings, including sill, jambs and lintels		**10**
-New walls and infills		**3**
-Strengthening select walls with mesh plaster		**7**
-Installing missing confining columns (corners/free ends/bracing long panels)		**9**
Type 3: Basic RF + EQ Damage Repair	**2,660**	**38**
-Installing missing confinement at wall openings, including sill, jambs and lintels		**10**
-Demolition and construction of new walls to repair EQ-damaged ones; opening infills		**12**
-Strengthening select walls with mesh plaster		**7**
-Installing missing confining columns (corners/free ends/bracing long panels)		**9**
Type 4: Basic RF + Slab Roof Replacement**	**6,370**	**91**
-All interventions as listed for the Basic Retrofit (Case 2)		**30**
-Replace roof with reinforced concrete slab roof		**61**
Type 5: Basic RF + Light Roof Replacement**	**6,580**	**94**
-All interventions as listed for the Basic Retrofit (Case 2)		**30**
-Replace roof with lightweight roof system		**64**
TYPICAL UNREINFORCED BRICK MASONRY HOUSE		
Basic Retrofit (excludes repair of EQ damages)	**5,530**	**79**
-New roof system***		**49**
-Strengthening of corners		**19**
-Fixing missing lintels and columns at free ends		**11**

* Values listed include costs for materials and labors but do not include costs related to transport of material to the construction site or technical assistance.

** Roof replacement is necessary in many cases where the existing slab is deteriorated due to weathering and poor construction quality, and/or damaged by the earthquake, or where the existing lightweight roof did not comply with the required quality. Homeowners indicated a preference for slab roofs due to interior temperature and waterproofing concerns.

*** The majority of these buildings have an existing tile roof, supported on a timber frame that is generally in poor condition, not sufficiently connected to the ring beam. For this reason, the retrofit intervention proposed generally includes replacing the roof with a structurally compliant roof.

EXAMPLE 1

New house built with subsidy presenting deficient connections between the roof and walls and poor construction detailing of reinforced concrete elements (insufficient cover and excessive distance between confinement bars).

Photos: MEX-BC_e4600491, home of Marina Jacinto Suárez, Tehuantepec 2019.

EXAMPLE 2:

New house built with subsidy.

Observed deficiencies:

- Lack of confinement around wall openings that might generate wall failure in case of an earthquake.
- Thin locally procured block, with low compressive strength.
- Lack of shear wall area.

Photos: MEX-BC_8c4bd59b, home of Alfredo Rasgado Ordaz, Ixtaltepec 2019.

SOURCE: BUILD CHANGE.

LEARNING FROM SUCCESSFUL INTERNATIONAL HOUSING RETROFITTING EXPERIENCES

Mexico's home improvement initiatives can also learn from programs implemented in other countries. A review of retrofit programs implemented in the United States and Japan commissioned by the World Bank (Miyamoto 2019), offers several valuable lessons and recommendations:

- Digital imaging and machine learning can be used to identify the different existing building types. Other sources of information such as census data, city development patterns, and site surveys can supplement this data and verify its accuracy. Once the building types are known, a prioritization of those that cause larger losses of lives should be carried out.

- Buy-in from the various relevant stakeholders is critical in the project development phase, during which inputs from developers, government officials, engineers, potential financers, and the public can be obtained to shape the program. The lack of understanding of disaster risk and knowledge on safe construction is a primary reason for the lack of action on mitigation. In this phase, communication and information strategies are key to create awareness about the importance of ensuring that buildings are structurally safe. Local forums for the exchange of ideas among the various stakeholders as well as between different cities can be organized. Web-based information portals can also help educate the public and disseminate information about the project and serve as repository for relevant documents.

- Regulatory capacity and compliance of housing retrofit programs can be enhanced by capacity building activities targeted at government staff and stakeholders, including engineers, architects, masons and contractors, in both the formal and informal sectors in the target area.

- A flexible menu of financial assistance schemes can help convince the population to participate in the program. This menu could include long-term low-interest-rate loans, local or national government grants, compensation through property taxes, more favorable financing terms for safer buildings, some pass-through costs, and reduced property insurance.

- Long term programs can help ensure a higher rate of compliance. In some urban centers with massive numbers of vulnerable houses, a retrofit program could take years or even decades to be completed. Setting a long-term schedule can also ease the securing of funds by house occupants, thus promoting compliance. A phased approach can be used; for example, allow some time for screening, followed by development and submittal of retrofit plans, and then a number of years to complete the actual work.

- It is important to develop regulatory instruments, such as codes for new construction, retrofit guides for multi--unit buildings, and handbooks for single-unit building and enforce their compliance. For smaller units, residents can do some of the basic retrofits themselves at a low cost if they have some basic training or booklets to reference and if they can borrow tools from the city.

- Develop the methodology for creating a pilot project in a vulnerable city. This task involves project development, including all key components such as regulations, financing, engineering, and outreach. References listed in this document can provide more detail on the various stages of the program development.

- Implement a small-scale pilot project for a district in a city that is based on the developed methodology. Use it as a test case to refine the program for more general application. The success of such a program will help to obtain buy-in from various stakeholders, to ensure that the program is transparent, and to encourage participation by incorporating suggestions for improvements.

HOW THE MEXICAN GOVERNMENT ALLOCATES SUBSIDIES CAN EITHER INCREASE OR DECREASE THE RISK OF THE HOUSING STOCK.

4. Conclusions

After completing the research on Mexico's housing policies and institutional framework, as well as the pilot intervention in the Istmo de Tehuantepec, the team has arrived at the following conclusions:

- The Mexican government has correctly identified the need to focus on sustaining reconstruction efforts and promoting resilience and social inclusion. Although it is necessary to continue working in the production of new housing, Mexico's qualitative housing deficit is significant. In a country where the majority of the population inhabit areas vulnerable to catastrophic events, resilience should be an important component of every home improvement intervention. Governments can either increase or decrease risk with the allocation of housing subsidies.

- However, several policy aspects require further development before the government's vision can be realized. It currently does not possess the necessary data to inform policy decisions on where and which houses to intervene, the retrofit interventions required for each type of vulnerability, and the financial products that meet the needs of the different population segments. To further develop its policy approach, the government needs to collect this information more efficiently.

- The experience and reach of Mexico's institutional set up, lessons learned through decades of implementation of housing policies and programs, complementary hazard information and recent technological advances can help close the existing institutional, policy and information gaps. But there is also a need to act at the housing unit level, for which detailed and complete information is required. Traditionally, obtaining this information has entailed long, labor intensive and costly processes. Today, however, the methodology proposed by the bank can save money and time and increase precision.

- The Bank's methodology for the assessment of the housing stock proved to be affordable, reliable, and scalable. The fieldwork, which was conducted in two weeks, can be replicated in other areas of the country. The cities of Salina Cruz and Juchitán de Zaragoza present several similarities but also differences on size, terrain, and prevalence of different construction materials. These differences provided an opportunity to test the bank's methodology on different environments.

- The pilot intervention in the Istmo de Tehuantepec showed that the application of this methodology could help CONAVI reach the most vulnerable segments of the population with a strong value proposition that combines physical security, quality of life and respect for the use of local materials and construction practices.

NEXT STEPS

The next step is the proof of concept of the feasibility of applying the vulnerability assessment methodology at scale, extending the scope to a greater area. Based on the results of this pilot, a functional model can be adjusted for application in other municipalities in the state of Oaxaca or in other regions that are exposed to different hazards, with distinct geographical, sociocultural and economic conditions, so that the model can be used for multiple hazards and locations.

As a result of the proof of concept, valuable input can be provided to the government of Mexico for improving the targeting and delivery efficiency of housing programs, including resilience at their core. The approach to "build better before" provides a great opportunity to address housing vulnerabilities, improve coordination between public and private organizations and provide specialized technical assistance to guide and accompany home improvement and self-construction processes. Additionally, the methodology an technological tools applied can can be used for other objectives such as property valuation and tax collection, as is being done in Peru and Colombia, thus addressing the challenge of better linking housing, urban governance, and disaster risk management policies. Most importantly, a renewed focus on housing resilience allows to put the most vulnerable and largely underserved population at the core of Mexico's housing assistance model.

HAZARDS POSE THEIR GREATEST THREATS TO SUBSTANDARD HOUSES, AND THE FAMILIES LIVING INSIDE.

ANNEX 1
Imagery Collection and Analysis

To inform the allocation of home improvement subsidies, spatially explicit and comprehensive data is needed. In the cities of Salina Cruz and Juchitán the team created a rich housing stock database to demonstrate the technical feasibility and resulting benefits of such data. Images of the urban housing stock were taken from the sky (with drones) and from the ground (with a street view camera). Later machine learning algorithms were applied to extract pertinent information about each building. This Annex provides technical information on this exercise.

Drones

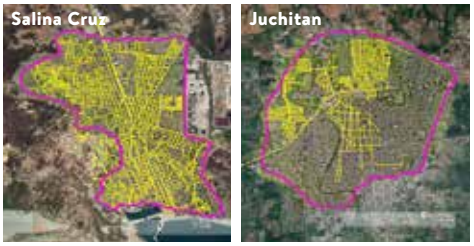
Fixed-wing eBee X drones were flown over the city of Salina Cruz and Juchitán –producing 3.6 cm resolution natural color images and a 7.1 cm digital elevation model (surface and terrain). This imagery was then mosaiced and ortho-mosaiced to achieve a positional accuracy of ~50 cm with the use of Real-time Kinematic (RTK) positioning. More specifically, these EBee X endurance activated drones were carrying SODA 3D sensors so that building and terrain height could be modeled. The pilots faced several challenges in the field –strong wind (up to 12 mph daily), steep terrain, and minimal access to take-off and landing sites. Despite these challenges, within 6 days two pilots collected 31.3 km^2 of land. The drone imagery extracted covered 20 km^2 in Salina Cruz and 11.3 km^2 Juchitán).

DRONE COVERAGE

Street view

For the street view images, a Trimble MX7 camera was mounted to an SUV resulting in 360-degree image every 2 meters. This camera has 6 lenses and can enhance the precision of location data derived from satellite-based positioning systems (global navigation satellite systems, GNSS) and Real-time Kinematic (RTK). In the city of Salina Cruz every navigable road was driven resulting in a total of 579 km, and in Juchitán, roughly 136 km were captured. The street view team also faced challenges –such as a tropical depression (heavy rain), steep terrain, unpaved roads and dead-end streets.

STREET VIEW COVERAGE



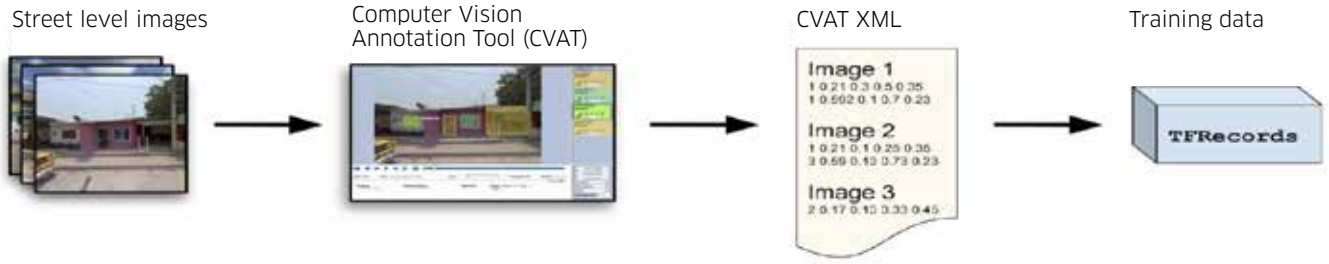
Protests and deteriorating security conditions resulted in less than anticipated street view data collected in Juchitán. Despite these challenges –337,263 panoramic images, 2,023,578 cube images and more than 5.63 TB of data were collected.

Analysis

Once drone and street-view images were collected, machine learning algorithms were trained to extract certain characteristics of each house.

To analyze the street view, the team stood up an open source annotator (CVAT) and ran the model on using Tensor-

WORKFLOW FOR STREET VIEW MACHINE LEARNING



flow's Object Detection API. The model was built using over 50,000 labels and predicted 9 different characteristics, resulting in a total of 140,625 predictions in Salina Cruz and 65,754 predictions in Juchitán.

From the drone images, rooftops were delineated, then 6 characteristics were generated: height of roof, area of roof, volume of building, terrain slope, roof material and condition. Finally, all street view characteristics were attributed to the build footprint layer using the cardinal direction and trajectory information from the street view image.

The result of all this imagery collection and machine learning is that for each building with have up to 15 attributes.

Results

This exercise demonstrated that within a short amount of time, it is possible to generates a detailed geospatial database that provides decision makers with valuable information regarding the housing stock that they are responsible for. In Salina Cruz and Juchitán, where seismic activity frequently damages homes, understanding the quality and materials being using in the construction is vital. Furthermore, this approach allows for the detection of buildings that are likely to collapse during an earthquake –i.e tall buildings with large weak walls (large windows and garages). Such structures can now be flagged and examined further by engineers in the field. Lastly, when integrated with field work, this database allows for the creation of a building typology. For example, during this exercise experts in the field determined that residential buildings that are 100 square meters large, constructed of brick/plaster, will cost USD 50 a meter for retrofitting. This database can be queried to locate and provide a cost estimate for retrofitting all such buildings in the City of Salina Cruz. The ability to extract such knowledge as the potential to inform Mexico's urban management policies in the field of disaster risk management (DRM), infrastructure planning, and climate change mitigation.

ANNEX 2
Main actors in the Mexico housing sector

Mexico's housing sector is made up of multiple public and private actors that are involved in the design, financing and development of social housing. In the last 45 years, more than 120 entities have had a stake in Mexico's housing policy. Today, the main institution responsible for policy design in the housing sector is the Ministry of Agrarian, Territorial and Urban Development (SEDATU). The main executing body of SEDATU in the housing sector is the National Housing Commission (CONAVI), alongside other public and private entity including the National Housing Funds, state housing agencies at state level and other entity with co-responsibility in the housing sector.

NATIONAL HOUSING AGENCIES (ONAVIS)

- **SEDATU** (Ministry of Agrarian, Territorial and Urban Development). It is the agency of the Federal Public Administration that has as its main purpose is to plan, coordinate, manage, generate and execute public land planning policies, guarantee decent housing to all, and manage urban and rural development.
- **CONAVI** (National Housing Commission). Created in 2006, it has been an important operator of federal housing subsidies. Previously it acted as coordinator of housing policy but those responsibilities have been transfered to SEDATU and CONAVI is currently in charge of operating the federal subsidy programs.
- **INFONAVIT** (Institute of the National Housing Fund for Workers). Created in 1972 as a housing fund for salaried workers in the private sector. Its resources come from the mandatory savings of employees and companies that are discounted via payroll. INFONAVIT is the largest mortgage lender in Mexico; it mostly focuses on financing new housing developments.
- **SHF** (Federal Mortgage Company). It is the second most important lender by volume of credits. In 2011, it became a second-tier banking entity.
- **FOVISSTE** (Housing Fund of the Institute for Social Security and Services of State Workers). It is the equivalent of INFONAVIT for public sector employees and is approximately one tenth in size, according to the number of affiliates.
- **FONHAPO** (National Fund for Popular Rooms). It was created in 1982 with the objective of serving the poorest segment of the population through targeted housing interventions. FONHAPO was closed in 2019 and its functions were transferred to CONAVI.

STATE HOUSING ORGANIZATIONS (OREVIS) AND MUNICIPALITIES

Each of the 32 States of Mexico has a State Housing Agency financed with state revenues, as well as several municipal institutes. The volume of operation of these entities represent only a fraction of the subsidies provided by the federal government.

OTHER ENTITIES WITH HOUSING ASSISTANCE SCHEMES

A number of specialized housing funds operate alongside INFONAVIT and FOVISSTE, such as ISSFAM (Institute of Social Security for the Mexican Armed Forces). Other institutions also operate dedicated housing assistance programs such as CFE (Federal Electricity Company), PEMEX (Petróleos Mexicanos) and some non-profit organizations such as Habitat for Humanity Mexico.

In addition, the Ministry of Social Development (SEDESOL) has operated significant volumes of housing improvement actions focused on the poorest population segments.

PRIVATE SECTOR

Many private entities such as micro-finance institutions, cooperatives and popular savings banks provide access to finance for home improvement. Some private entities also offer technical assistance services. The private sector also plays a role in the provision of construction materials.

ANNEX 3
A note on terms and definitions

The purpose of this note to guide the reader about the terms and definitions used in this report. Regarding the housing deficit, official sources point to different estimations of Mexico's qualitative and quantitative housing deficit. The Government refers to both the deficit identified in the National Information System and Housing Indicators (SNIIV) (9.2 million households, representing 28% of the total number of households based on 2015 census data) and the deficit calculated by CONEVAL (2018), which estimates the national housing deficit to amount to 14 million, or 45% of the overall housing stock. In the report, a table is included in page 11, which contains the housing deficit estimates used by different entities. For this report, the quantitative housing deficit is understood as the gap existing between the demand for housing and the existing housing stock. Furthermore, the qualitative housing deficit refers to the housing units that are inadequate as defined by UN Habitat, namely as lacking one or more of the following elements: access to water, access to sanitation, sufficient living area, structural quality, durability and location, security of tenure, affordability, and accessibility and cultural adequacy.[1]

The report also refers to home improvement interventions. They can be defined as those interventions that seek to expand housing, make repairs, provide basic services or any other improvement in the quality of housing. It includes retrofit interventions, which are understood as those consisting on repairs, reinforcements or additions of housing features to reduce the risk of collapse.

Finally, this report revolves around resilient housing in the context of an increasingly urban Mexico. A World Bank report (2014) defined resilience in an urban context as the "ability of a system, entity, community, or person to adapt to a variety of changing conditions and to withstand shocks while still maintaining its essential functions".[2] In relation to housing, resilience can be understood as the capacity of housing units to protect lives and/or assets when unfavorable events occur.

[1] UN-Habitat (2018). SDG Indicator 11.1.1 Training Module: Adequate Housing and Slum Upgrading. United Nations Human Settlement Programme (UN-Habitat), Nairobi. Available at: https://unhabitat.org/wp-content/uploads/2019/04/Indicator-11.1.1-Training-Module.pdf

[2] World Bank. 2014. "An expanded approach to Urban Resilience: Making Cities Stronger." Washington DC, in GFDRR (2015) "Investing in Urban Resilience". Available at: https://www.gfdrr.org/sites/default/files/publication/Investing%20in%20Urban%20Resilience%20Final.pdf

ANNEX 4
Glossary of abbreviations

AO	*Administrador de Operaciones* –Operations Administrator.
ASA	Advisory Services and Analytics.
CENAPRED	*Centro Nacional de Prevención de Desastres* –National Disaster Prevention Center.
CIDOC	*Centro de Investigación y Documentación de la Casa* –Housing Research and Documentation Center.
CONAVI	*Comisión Nacional de Vivienda* –National Housing Commission.
CONEVAL	*Consejo Nacional de Evaluación de la Política de Desarrollo Social* –Nacional Council for Evaluation of the Social Development Policy.
EGIR	*Estrategia de Gestión de Riesgo Integral de México* –Integral Risk Management Strategy of Mexico.
ENIGH	*Encuesta Nacional de Ingresos y Gastos de los Hogares* –National Survey of Household Income and Expenses.
FONDEN	*Fondo de Desastres Naturales* –Natural Disasters Fund.
FONHAPO	*Fondo Nacional de Habitaciones Populares* –National Fund for Popular Housing.
FOVISSSTE	*Fondo de Vivienda del Instituto de Seguridad y Servicios Sociales de los Trabajadores del Estado* –Housing Fund of the Institute of Social Security and Services of State Workers.
GIZ	German Corporation for International Cooperation.
INEGI	*Instituto Nacional de Estadística y Geografía* –National Institute of Statistic and Geography.
INFONAVIT	*Instituto del Fondo Nacional de la Vivienda para los Trabajadores* –Institute of the National Housing Fund for Workers.
OEO	*Entidad Ejecutora de Obras* –Works Executing Entity.
ONAVIS	*Organizaciones Nacionales de Vivienda* –National Housing Organizations.
UN Habitat	United Nations Human Settlements Program.
OREVIS	*Organizaciones Estatales de Vivienda* –State Housing Organizations.
PCU	*Perímetros de Contención Urbana* –Urban Containment Perimeters.
RUV	*Registro Único de Vivienda* –Single Housing Registry.
SEDATU	*Secretaría de Desarrollo Agrario, Territorial y Urbano* –Ministry of Agrarian, Territorial and Urban Development.
SEDESOL	*Secretaría de Desarrollo Social* –Ministry of Social Development.
SEMARNAT	*Secretaría de Medio Ambiente y Recursos Naturales* –Ministry of Environment and Natural Resources.
SHF	*Sociedad Hipotecaria Federal* –Federal Mortgage Society.
SNIIV	*Sistema Nacional de Información e Indicadores de Vivienda* –National Information System and Housing Indicators.
UMA	*Unidad de Medida y Actualización* –Unit of Measurement and Update.
USD	US Dollar.