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Introducing the Adequate Housing Index (AHI)

A New Approach to Estimate the Adequate Housing Deficit within and across Emerging Economies

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Abstract

This paper introduces a micro-founded methodological framework to estimate the housing deficit across and within emerging economies. It introduces the Adequate Housing Index, which provides a comparable assessment of adequate housing based on seven adequacy dimensions that are held constant across all countries. The adequacy dimensions were obtained and harmonized from countries' most recent household expenditure and consumption surveys. The paper documents large differences in housing adequacy across a sample of 64 emerging economies, as well as wide within-country disparities such as across income groups, locations, and occupations. Estimates of the Adequate Housing Index show that across the sample of 64 emerging economies, there is a current housing deficit of 268 million housing units affecting 1.26 billion people. About 26 percent of the current housing stock in these economies is inadequate. The paper further estimates that at least 40 million additional housing units will have to be added by 2030 to provide adequate housing to all and accommodate the growing population and urbanization patterns.

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1. Introduction

Globally, about 55 percent of the world's population resides in urban settlements. It is expected that this proportion will increase significantly by 2030, adding an estimated 1.6 billion people to urban areas. About 90 percent of this increase is projected to take place in Asia and Sub-Saharan Africa, particularly in India, China, and Nigeria (UN 2020). Unprecedented population growth and urbanization put pressure on the housing market as increased demand for housing often outpaces the construction of new homes. The demand for housing, particularly in urban areas, will very likely further rise due to socio-demographic transition processes, changes in intra-household (HH) dynamics, or increased migration flows due to climate change. To understand the forward-looking housing demand that economies will face in the coming decade (the flow deficit), we need a thorough understanding of the inadequacy of existing housing (the stock deficit).

Therefore, in this paper, we introduce a new *Adequate Housing Index (AHI)*, which is based on a uniform methodology to quantify housing deficits across emerging markets. The *AHI* draws on countries' latest HH expenditure and consumption surveys (HCES) to estimate the adequacy of housing conditions at the HH level. The uniform measure of the *AHI* allows for comparability across countries, provides an assessment of the general state of housing within a given economy, and allows to raise awareness regarding the overall housing situation within a given country. We implement the *AHI* for 64 emerging economies representing about 88 percent of emerging markets' population, excluding China. We select these 64 emerging economies based on data availability, income group, population size, and region.

Access to an adequate place to live is fundamental for economic well-being, human dignity, physical and mental health, and overall quality of life. Low-quality housing is often observed in slums or informal settlements, in which most urban poor HHs live and work (Bah et al. 2018). Yet, finding an adequate house is also often a challenge for urban dwellers in formal settlements, for low- and higher-income HHs alike. Particularly, the current COVID-19 pandemic has highlighted the urgent need for adequate housing to cope with the health crisis for all segments of the population. Families who live in sub-standard or inadequate housing units often suffer from overcrowding, poor construction to protect them from heat, cold or rain, inadequate access to water, sanitation, and other basic services, and insecure property titles. These poor housing conditions often have detrimental consequences for families' health and/or economic well-being. Housing is, therefore, included as a key principle in the United Nations' (UN) 2030 Agenda for Sustainable Development and reflected in Sustainable Development Goal (SDG) 11, which targets access for all to adequate, safe, and affordable housing and basic services and upgrading slums (target 11.1).

Despite the recognition of housing being a driver for social and economic well-being, existing data on adequate housing and on the respective housing deficit within and especially across emerging economies are scarce. Within countries, there is a wide disparity across income segments when it comes to the quality of housing. Housing quality also varies significantly across other HH characteristics such as location, education, occupation, and gender. These within-country dynamics of housing deficits are often conceptually noted, yet not quantified in a way that is actionable for policy makers and private sector companies along the housing value chain. In addition, existing country-specific figures are often outdated. Nigeria, for instance, the most populous country in Africa, with an urbanization rate of 4.8 percent, since 2000, is estimated to have a housing deficit of at least 17 million. This figure is steadily cited for the last decade, not factoring in the rapid population growth that might have increased the deficit (Bah et al 2018: 7). Globally, the UN estimates that about one billion people live in makeshift structures lacking at least one of the basic services which jointly constitute adequate housing, projecting that the number will rise to 3 billion people by 2030 (UN-Habitat 2012; UNDESA 2013; UNSD 2019). Yet, this is a broad projection mostly estimating the number of people living in slums and is therefore likely underestimating the number of urban dwellers in formal or informal settlements who are lacking access to these basic services.

While providing valuable insights, existing housing deficit estimations, which often rely on macro-level data, hitherto lack a global standard and a consistent underlying framework that allow for cross-country comparison of deficit numbers. Micro-founded analyses across countries, applying the same rigorous methodological approach to estimate housing deficit for different segments of the population, are, largely, absent. A key constraint to establishing a uniform methodology is often the limitation to consistently identify what qualifies as adequate housing across and within countries. Addressing this void, in this paper, we introduce a micro-founded methodological framework to estimate the housing stock and flow deficit by building up from the adequacy of housing at the HH level. We define housing adequacy based on seven dimensions which are consistently found to be relevant for HHs' health, educational attainment, and overall economic well-being, and which are embedded in the Agenda 2030: (1) access to improved water; (2) access to improved sanitation; (3) adequate living space; (4) durable material and good structural quality; (5) security of tenure; (6) access to electricity; (7) access to clean cooking (cf. next section).

We introduce a uniform framework for the novel *Adequate Housing Index (AHI)* that provides a comparable assessment of these seven adequate housing conditions across emerging economies. We implement the *AHI* by estimating the aggregate stock deficit across and within 64 emerging economies. We estimate that at least 268 million HHs (about 1.26 billion people) currently live in inadequate housing conditions across 64 emerging markets. We estimate that an *additional* 40

million housing units will have to be added to provide adequate housing to the growing population by 2030. Regarding the deficit at the dimension level, we estimate that at least 603 million HHs (close to 2.8 billion people) in emerging economies lack access to at least one of the seven dimensions of adequate housing. Our prediction indicates that not only HHs residing in slums are lacking access to adequate housing, as the UN estimation suggests (UNSD 2019). Instead, the housing deficit is much more wide-ranging, extending to HHs in formal settlements.

In constructing the AHI, we present a transparent framework for harmonizing seven dimensions of housing adequacy recorded in countries' most recent HH surveys. To the best of our knowledge, this is the first broad, cross-country study applying a uniform methodological framework on housing adequacy and related housing deficit estimations. This cross-country assessment of existing adequate housing deficits will facilitate consistent projections of how the adequate housing deficit will rise within the context of urbanization and population growth.

In our analysis, we highlight important within-country variation in housing needs across different segments of the population. Further, in separately estimating the current housing deficit and the forward-looking deficit likely to manifest over the next decade, we draw a fundamental distinction between the stock and flow housing deficits. This differentiation is often not appropriately stated in existing estimations of housing deficits. Instead, stock and flow deficits are frequently used interchangeably, partly because only one type of estimation is available for the country.

The remainder of this paper proceeds as follows: in the next section, we briefly discuss how our approach relates to existing literature on estimating housing deficits and outline how literature assesses the relationship of housing adequacy and socio-economic outcomes. We discuss how recent estimations of housing deficit largely abstain from differentiating between the stock deficit of currently inadequate housing units and the flow deficit – often referred to as the quantitative housing deficit denoting how many additional housing units will have to be built. Next, we outline our methodology in constructing the *AHI,* which is the basis for the housing stock deficit estimation and discuss the various data sources we use. Thereafter, we present results of the aggregate *AHI* for 64 countries and its respective adequacy components. We discuss within-country adequacy deficits, segment the population into income deciles, and disaggregate the *AHI* on other dimensions such as location, education, gender, or occupation. Next, based on the *AHI* and other demographic projections, we estimate the current housing stock deficit as well as the flow deficit of housing likely to arise by 2030 with business-as-usual policies and private sector practices. Finally, we offer a brief conclusion outlining how the *AHI* can help identifying adequacy housing needs of different segments of the population so that housing interventions can be more targeted, appropriately designed, and implemented. We conclude by outlining avenues for future research.

2. Literature Review: Housing Deficit and Adequate Housing

Our paper contributes to the existing literature in several ways. First, it adds to the literature that estimates the housing deficit at country, regional, and global levels. Second, our work relates to the literature on housing adequacy that investigates (different dimensions of) adequate housing within and across countries relating them to socio-economic and health outcomes. Our work extends the literature by providing a comparable methodology that allows for a micro-founded analysis of housing adequacy across many emerging economies. In the following paragraphs, we discuss these two strands in more detail.

2.1 Housing Deficit

The term 'housing deficit' is very prevalent in newspaper articles, academic literature, and policy papers. Yet, the term is rather ambiguous, relies heavily on assumptions that are seldom explicitly stated, and often lacks conceptual clarity (for an overview on the various definitions of housing deficit refer to World Bank (2020a)). Within academic literature, the term housing deficit usually refers to two separate but intertwined notions: (i) the quantitative housing deficit – commonly also referred to as housing backlog – measuring the numerical shortfall in housing units, and (ii) the qualitative housing deficit estimating how many HHs live in sub-standard houses based on the quality and condition of housing units and access to basic services (e.g., Bah et al. 2018; Bouillon 2012; UN-Habitat 2016; World Bank 2015).

Although both ideas refer to deficiencies in the housing stock, the conceptual differentiation between these two notions are often ambiguous and rarely explicitly stated outside formal publications. Traditionally, the *quantitative* housing deficit is conceptualized as the difference between the number of HHs and the number of available dwellings. Over time, many authors added some qualifying aspects to this rather broad definition. In these expanded definitions, the quantitative housing deficit includes HHs that share a home with other families, HHs without access to individual housing, HHs that occupy homes of a very precarious nature, with severe structural deficiencies, or severely dilapidated and inadequate beyond repair (e.g., Habitat 2016; Olaya et al. 2017; Szalachman 2000). Often problematic in the estimation of the quantitative housing deficit is the absence of reliable (national accounts) data regarding the number of available dwellings and HHs. Hence, authors often rely on proxy estimations such as simple models of changes in household formation (e.g., Monkkonen 2013).

The *qualitative* housing deficit broadly subsumes houses that are inhabitable or lacking basic quality standards. Definitions on these standards, however, vary significantly and the number and type of adequacy conditions included into estimations are seldom homogenous across studies. Many publications conceptualize the *qualitative* housing deficit to include HHs with (some or all)

deficiencies in infrastructure (lack of water, sanitation, and/or electricity), HHs that are built with inadequate materials (walls, roofs, and floors), and HHs that are overcrowded (e.g., Cristini and Moya (2008) cited in Lora et al. (2010); Szalachman 2000). Some authors expand this definition adding aspects such as insecurity of tenure (e.g., Habitat 2016), telephone coverage (e.g., Lora et al. 2010), or location and accessibility to markets (e.g., Acolin & Green 2017; Isalou et al. 2014). Others proxy the qualitative housing deficit by focusing on one qualitative aspect only such as access to drinking water (e.g., Gilbert 2001; ECLAC 1996). Yet another alternative to estimating the qualitative housing deficit is to survey HHs' satisfaction with their homes. Gallup recently conducted such a perception-based survey asking respondents about their satisfaction with the availability of good, affordable housing. The results highlight a wide gap in satisfaction levels across countries which reflect the diversity of housing markets across the world (Gallup 2021).

These varying definitions and approaches towards the qualitative and quantitative housing deficit are particularly problematic when comparing deficit numbers. Diverging definitions of adequacy lead to different estimation methodologies of housing deficits and therefore render the comparison of housing deficits across studies meaningless. This becomes particularly apparent with the varying scope and number of qualitative dimensions considered to contribute to the qualitative housing deficit across studies. In particular, the aspect of overcrowding is ambiguous. It is sometimes considered to be contributing to the qualitative housing deficit, the quantitative housing deficit, or to both. A recent World Bank study regarding the housing deficit in Peru, for instance, highlights the impact of varying adequacy definitions. The study shows that the qualitative housing deficit equivalent to 23 percent of the country's housing stock could rise to 68 percent when a stricter definition of housing adequacy is applied (World Bank et al. 2021: 26).

Based on their respective definitions, there are numerous within-country studies on the housing deficit. These studies focus predominantly on the mismatch between housing demand and the estimated existing dwelling stock for a particular country or several cities (e.g., Bower et al. 2019; Olaya et al. 2017; Szalachman 2000; UN Habitat 2011; Yoshino & Helble 2016). Different studies come to different conclusions as to how many housing units are missing – even for the same country. UN-Habitat's *Ghana Housing Profile*, for instance, compares different deficit calculations for Ghana, identifying eight distinct estimations within the literature, which range between 250,000 and 1.5 million housing units depending on the sources used and the definition and calculation method applied (UN-Habitat 2011). Similarly, in several studies on Indonesia, housing deficit estimations range between 3 million and 14 million missing units (for a critical overview on the several methodologies: Monkkonen 2013). The absence of a common definition, a transparent and uniform methodology to estimate deficits, and the missing distinction between

the existing stock and forward-looking flow deficits are likely contributing to the confounding range of housing deficit estimations within the same country.

Some within-country studies provide an estimation of *both* the quantitative and qualitative housing deficits for individual countries identifying mediating instruments to cope with population growth, urbanization, and an imminent shortage of housing units (e.g., Libertun de Duren & Osorio 2020a; Nenova 2010; Pecha-Garzón 2011). Some of these within-country studies even provide a nuanced assessment of which segment of the population is usually underserved within a country or why the over-provision of housing for certain segments in the wrong location might lead to "ghost cities" (e.g., Ying et al., 2013; López and Blanco 2014). Generally, housing for the poor majority of the population has received lower attention in many emerging countries and the private sector has been left to take up the initiative in formal housing supply, often resulting in provision of housing units to the solvent top few percent of the population (UN-Habitat 2016).

For both the estimation of the qualitative and the quantitative housing deficit, there are few cross-country studies applying a standard methodology for a larger set of countries. Some exceptions estimate the current housing deficit and how many new housing units have to be built to bridge the quantitative housing gap (e.g., Bah et al. 2018; Bouillion 2012; Woetzel et al. 2014; UN-Habitat 2009). Tusting et al. (2019), for instance, provide a recent study on *changes* in housing conditions in Sub-Saharan Africa between 2000 and 2015. Focusing on three dimensions – improved water and sanitation, sufficient living area, and durable construction – the authors find a transformation of housing in urban and rural Sub-Saharan Africa doubling access to improved housing from 11 to 23 percent. In addition, in a recent study, Brown et al. (2020) assess the adequacy of developing countries' home environments for protection from the current COVID-19 virus, showing that 90 percent of the global poor are unable to fully comply with recommendations by the WHO to protect from the virus.

Overall, the lack of agreement on standards, objective definitions, and the shortage of comparable country level data makes the estimation of (qualitative and/or quantitative; stock and/or flow) housing deficits difficult.

2.2 Housing Adequacy and Socio-Economic Outcomes

International human rights conventions have long recognized the importance of housing. The right to housing is enshrined in the 1948 Universal Declaration of Human Rights and in the 1966 International Covenant on Economic, Social and Cultural Rights. At first very broadly captured as the right to live in security, peace and dignity, a number of conditions have been put forward in general comments by the UN's Committee on Economic, Social and Cultural Rights (CESCR) that

must be met before shelters can be considered "adequate".[2] These conditions can be subsumed as follows: security of tenure, affordability, habitability, availability of services and infrastructure, accessibility, location, and cultural adequacy. Since then, most literature on housing adequacy revert to UN-Habitats (2016) five factors of defining a slum when assessing housing adequacy: (1) access to improved water, (2) access to improved sanitation facilities, (3) sufficient living area, (4) structural quality / durability of the housing unit, and (5) security of tenure.

These housing adequacy criteria have triggered a myriad of scholarly research examining how housing adequacy relates to a series of socio-economic outcomes, including health, emotional well-being, social belonging, education, economic attainment, political participation, or job creation (e.g., Thomson et al. 2001& 2009; or WHO 2018 for an overview). These usually micro-founded analyses provide adequacy assessments of existing housing units on one or two of these dimensions within or across countries.

Many articles establish a positive link between piped water into households or plots and reduced diarrhea prevalence and mortality in young children (e.g., Galiani et al. 2005; Jalan & Ravallion 2003; Jamison et al. 1993; Nabassaga et al. 2019). Further, positive links are established between piped water and improvements in overall well-being and life satisfaction through significant time gains as households spend less time in fetching water (e.g., Devoto et al. 2012; Kremer et al. 2011).

Improved sanitation is a closely related housing adequacy component which has been amply demonstrated to improve health outcomes, particularly in children (e.g., Duflo et al. 2015; Wolf et al. 2014). Given the complementarities across water and sanitation, especially when considering the multiple pathways for transmission of water-borne diseases, some studies point to the fact that water and sanitation improvements are *jointly* responsible for most of the decline in child mortality rates and for health improvements (e.g., Cutler and Miller 2005; Watson 2006).

A series of studies also point to the beneficial effects of durable structural quality such as replacing dirt floors with cement floors. These improvements are highly correlated with reduction of child mortality rates, improvement of overall health, and adult welfare (e.g., Cattaneo et al. 2009; Bah et al. 2018).

Likewise, over-crowded houses, which are often classified as housing units with less than nine square meters per person or with more than three people occupying a room (e.g., Blau et al. 2019; Gove et al. 1983; UN-Habitat 2007), are often associated with adverse health outcomes (e.g., Bashir 2002; Cattaneo et al. 2009; Irfan et al. 2017; Krieger & Higgins 2002), violence (e.g., World

[2] Committee's general comments No. 4 (1991) on the right to adequate housing and No. 7 (1997) on forced evictions. General comments are adopted by the treaty bodies offering guidance to states on their obligations under the respective treaty.

Bank 1993), or under-development in children due to a lack of privacy (e.g., Evans 2006; Goux and Maurin 2005).

Further, security of tenure has consistently been found to have positive socio-economic outcomes (e.g., Deininger et al. 2015). Secured tenure is often the fundamental pre-requisite for other rights such as the right to vote (which often requires a registered address) or to apply for mortgages. Security of tenure has been found to be positively associated with economic and social outcomes, fewer evictions, and the development of the housing markets (e.g., Blau et al. 2019; Bouillon 2012; Holden & Ghebru 2013; Popham et al. 2015; Song 2020).

Location and proximity to service are also key adequacy housing components as they promote interaction between people and firms and instigate employment growth (e.g., Glaeser 2011; Hammam 2013; Venables 2015). The home environment can also put people at risk if HHs use unsafe material for cooking or electricity. Kerosene used for cooking and lighting remains widespread, particularly in Africa and Asia, and kerosene-related fires and explosions constitute a well-documented health hazard for millions of people (e.g., Lam 2012; Mashreky 2011).

2.3 Main Contribution

Several gaps emerge from this literature review. First, there is conceptual ambiguity regarding the term 'housing deficit'. Estimations on the qualitative housing deficit lack a global framework to approach the issue in a consistent manner across countries. We propose a replicable and comparable methodology that builds up from HH level. The application of this methodology allows for comparable estimates of aggregate housing deficits across and within countries. We provide a blueprint to estimate the deficit for emerging economies, and by way of application, estimate the housing deficit for 64 emerging economies. Also, we offer a clear-cut differentiation of the hitherto often intertwined connotations of housing deficit: we propose to first estimate the existing housing stock deficit by analyzing the adequacy of housing at the HH level, and then project the flow deficit of how many additional houses would have to be built to accommodate demographic changes by 2030.

Second, existing cross-country estimates of housing deficits are largely based on assessments at macro-level. These studies usually focus on the quantitative housing deficit estimating the mismatch between the existing housing stock and the demand for housing. By not taking into account the state and adequacy of the *current* housing stock, which particularly in low-income countries exhibits great deficiencies, many estimations are potentially underestimating the true need for housing as a large number of HHs are already living in inadequate housing units.

Third, the predominantly macro-derived estimates of the housing deficit miss key dynamics within countries for different segments of the population. Only few studies provide disaggregated estimations of housing deficits for different segments of the population (e.g., income groups). As a result, the needs of these segments compared to other countries, and the relative size of the housing deficit is often not fully understood. Through its micro-foundation, the methodology we propose allows not only for the segmentation within countries, pointing towards often veiled variation of housing adequacy, but also enables comparisons of disaggregated estimations (such as housing adequacy deficits in the biggest business city or deficits among the poorest income groups) across countries.

Fourth, in estimating the *AHI* using HH expenditure and consumption surveys for the respective countries, we are providing principles of global harmonization across seven dimensions of housing adequacy. Understanding HHs' access to these adequacy dimensions, such as access to water and sanitation, are key for monitoring progress towards the Agenda 2030. Our proposed harmonization can be considered a micro-founded supplement to existing country level measures of these adequacy dimensions. This might be helpful in providing a more nuanced picture of underlying issues for countries that are lagging behind. Also, applying these globalized standards to harmonize housing variables across HCES, we therewith expand the scope of work pioneered by the World Bank Global Monitoring Database (GMD), which is the World Bank's repository of multitopic income and expenditure household surveys used to monitor global poverty and shared prosperity.

Lastly, within the existing literature, the two realms on housing deficit and adequate housing conditions remain relatively separate. By introducing the *AHI*, we combine these two realms, outlining how inadequate housing conditions at the HH level contribute to the overall housing deficit. Hence, we move beyond narrow estimations of housing backlogs by only considering severely dilapidated or overcrowded houses and instead add other key dimensions of housing adequacy which have consistently been found to be a determinant of socio-economic development outcomes and which are a key driver to the realization of the right to housing reflected in SDG 11. As a result, estimates of housing backlog available in literature can be understood as a subset of our deficit projections reflected in the *AHI*. To the best of our knowledge, a global study applying a uniform methodological framework on housing adequacy and related housing deficit estimations is hitherto absent.

3. Methodology and Data: Constructing the *Adequate Housing Index*

We develop a global standard for estimating the adequate housing deficit based on seven adequacy criteria that we aggregate into the *Adequate Housing Index*. In the following section, we define these seven adequacy dimensions in more detail and further describe the multi-purpose household

consumption and expenditure surveys (HCES) that are our main data source for the seven adequacy dimensions. Also, we outline how we harmonize the individual variables in these HCES to ensure comparability across countries.

3.1 Housing Adequacy Dimensions

The construction of the *AHI* is based on the aggregation of seven adequacy dimensions which have frequently been found to be a key determinant for socio-economic and health outcomes (cf. Section 2.2), which are the key dimensions reflected in the Agenda 2030, and which are consistently available in micro-level household surveys which are our primary data source (Section 3.2): (1) access to improved water; (2) access to improved sanitation; (3) adequate living space; (4) durable material and good structural quality; (5) security of tenure; (6) access to electricity; and (7) access to clean cooking. All seven adequacy dimensions are coded as dummy variables differentiating adequate access (1) and inadequate access (0). The following paragraphs outline how we define and operationalize adequate access and how we harmonize these variables across surveys. We apply a uniform coding framework that allows for comparability across countries (a full, country-specific coding framework is available in the supplementary material upon request).

We align our coding of access to water (1) to the classifications of the WHO/UNICEF Joint Monitoring Programme (JMP). JMP defines improved drinking water sources as having the potential to deliver safe water by nature of their design and construction, including piped water, boreholes, or tube wells, protected dug wells, protected springs, rainwater, and packaged or delivered water (JMP 2020, Annex 1). We consider HHs that have access to improved drinking water to be adequate. We assume that HHs have inadequate access to water if they only have unimproved facilities at their disposal. Some countries' HH surveys capture the difference in access to water for dry and wet season (e.g., Tanzania or Nigeria). For these countries, we consider access to water as adequate if HHs have access to improved facilities in *both* wet and dry seasons. In Tanzania, for instance, more HHs use inadequate water sources during dry season. Adequate water sources HHs use during wet season (e.g., rainwater collection) seem to be largely unavailable to them in dry season. In contrast, few HHs revert from improved water sources in the dry season (public tabs, pipes, or boreholes) to unimproved water sources (surface water or unprotected springs) in the wet season, potentially due to the distance they have to cover to access public pipes in the dry season.

Regarding access to sanitation (2), we consider HHs to have adequate sanitation if they hygienically separate excreta from human contact. Adequate sanitation facilities include flushed toilet or pit latrines with slaps. JMP classifies adequate sanitation facilities which are shared between households as "limited service" on the sanitation ladder. Due to the absence of a large-

enough sample of comparable data, we consider improved sanitation facilities as adequate even if they might be shared between households.[3] Facilities such as pit latrines without a slab or platform, hanging latrines or bucket latrines are considered unimproved (JMP 2020, Annex 1).

With regards to adequate living space (3), we follow the widely used definition of over-crowding as a condition where the number of occupants exceeds the capacity of the housing unit's space. We adhere to a rather broad operationalization of over-crowding to ensure comparability across countries and regions, where different norms on e.g., children of opposite genders occupying the same room might exist.[4] We consider housing units to be over-crowded if there are less than 9 square meters per person or if more than three people occupy a room (cf. Blau et al. 2019; Gove et al. 1983; UN-Habitat 2007).

Regarding durable material and good structural quality (4), we consider the type of material used to build walls, roofs, and floors. While the categorization of material varies largely by region, country, and year in HH surveys, the various materials can be harmonized into durable or non-durable materials. We categorize housing material to be adequate if durable or finished materials such as burnt bricks, tiles, shingles, iron sheets, or polished wood are used. Unfinished, rudimentary, or natural materials include cane, straw, grass, or bamboo. We assume that an HH does live in an adequate house if all three materials for wall, roof, and floor are durable.

With respect to security of tenure (5), approaches to operationalize and measure are manifold, particularly across regions. This diversity is also reflected in the various coding schemes applied across various data sources. While there have been recent calls for a globally comparable (land) tenure module to be integrated into HH surveys (e.g., Holden et al. 2016), uniform data on security of tenure are hitherto absent within most multi-purpose HH surveys. Some (more recent) HCES include detailed questions on property titles or documents that HHs hold regarding their occupation status. In some African countries, some surveys include country-specific questions on e.g., (customary) certificate of occupancy, right to occupancy, or whether HHs hold formal title deeds

[3] For the 64 countries included in the *AHI*, data on shared sanitation facilities were not available for the majority of countries (Albania, Angola, Argentina, Belarus, Brazil, Burkina Faso, Burundi, Chad, Côte d'Ivoire, Colombia, Costa Rica, Democratic Republic of Congo, Djibouti, Dominican Republic, Arab Republic of Egypt, Ethiopia, Guinea, Guinea-Bissau, Haiti, Indonesia, Kazakhstan, Lao PDR, Madagascar, Mexico, Mozambique, Myanmar, Nepal, Nicaragua, Pakistan, Philippines, Peru, Romania, Russian Federation, Senegal, Sierra Leone, Sri Lanka, Togo, Tunisia, Turkey, Ukraine, Uzbekistan, Vietnam, and Zambia). This means we will not be able to identify HHs that share sanitation facilities and therefore likely share a housing unit with other HHs. As comparability across countries and a uniform coding scheme of the seven adequacy dimensions is our paramount objective; therefore, we opt not to differentiate between shared and non-shared sanitation facilities.

[4] Other agencies like Eurostat have a more nuanced classification defining an HH to be overcrowded if it does not have at least one room for the household; one room for each couple in the household; one room for each person aged 18+; one room per pair of single people of the same gender between 12-17 years or otherwise separate rooms; one room per pair of children under 12 years old (Eurostat 2014).

(e.g., Nigeria). This level of detail, however, is absent in most other economies' household surveys and only simple questions regarding ownership status are recorded. We define tenure security as the perceived tenure security as we deem the sheer ownership status of a housing unit too narrow of an estimate for tenure security. In order to measure perceived tenure security, we draw on a recent global perception-based survey of tenure security conducted by Prindex (cf. Section 3.2.3).

On access to electricity (6), we follow the definition of the International Energy Agency (IEA), custodian agency for SDG 7.2 on renewable energy. The IEA defines access to electricity as an HH having initial access to sufficient electricity to power a basic bundle of energy services, at a minimum, several lightbulbs, phone charging, a radio and potentially a fan or television.[5] This level of detail, however, is not available in most HCES. Hence, we apply a simpler measure. We classify HH as adequate if they are connected to an electricity grid, have a renewable stand-alone system, or have a mini-grid connection of enough capacity to deliver the minimum bundle of energy services mentioned above. In contrast, firewood, kerosene, torches, or gas lamps are considered inadequate sources of electricity.

Finally, we follow IEA's definition on access to clean cooking (7). We consider gas and electricity to be adequate cooking fuels. In contrast, solid fuels like biomass, wood, coal, or kerosene often used in traditional stoves for cooking, are considered inadequate.

These seven criteria are the most-often cited criteria of adequacy with clear links to HH welfare, and socio-economic and health outcomes within economic literature. Due to data limitations in HH surveys and to ensure cross-country comparison of the AHI, we abstain from including other variables that are often referred to as a prerequisite for adequate housing such as location, affordability, or cultural adequacy.

Regarding location, few data sources we use include information on where the household is located; or the variable is coded so diversely across countries that meaningful cross-country comparisons are impossible. Newer surveys in the LAC region, for instance, Mexico (ENIGHS 2018 survey) or Brazil (PNADC 2018 survey), include a variable on whether HHs live in a hazardous location.[6] Other regions, and older surveys, do not include such question (yet) and rather capture location through the distance to closest markets, schools, health facilities, or other services. Yet again, there are not enough comparable data points available across surveys. Surveys in

[5] https://www.iea.org/articles/defining-energy-access-2019-methodology

[6] In Brazil, for instance, of 151,864 HHs, 320 HHs are reported to live in a hazardous location – 0.02 percent, and in Mexico, 565 HHs of 73,513 HHs, 1 percent.

Tanzania (HBS 2018) or Uganda (UNHS 2016), for example, include these questions in their questionnaire, but the data is missing for virtually all HHs.

Likewise, variables on cultural adequacy, a criterion outlined in the CESCR, are largely absent in HCES surveys. Further, cultural adequacy is too context specific for a study that aims at cross-country comparability and largely depends on HHs' preferences, which are often not captured in available micro-level data.

Finally, on affordability, we are limited by the dearth of information from HCES surveys on housing expenditure in a consistent manner. To account for this important element, we propose pursuing a twofold approach: first, estimate the adequacy of a given housing unit and the related housing deficit and then (in future research) assess if alternate adequate housing is affordable to HHs based on existing housing finance conditions, HHs incomes, and comparable house price data.[7]

3.2 Data: Multi-Purpose HH Surveys

For the measurement of these seven adequacy dimensions and complying with our aim to construct a micro-founded *Housing Adequacy Index*, we rely on the 64 countries' most recent multi-purpose household surveys.

3.2.1 Household Consumption and Expenditure Surveys (HCES)

Our main data sources are household consumption and expenditure surveys (HCES) which are often carried out with support of the Living Standard Measurement Study (LSMS) program that was initiated by the World Bank Group in 1980. Many HCES, which are usually national representative surveys, collect data on a core set of questions on household consumption, expenditures, and income. The principal implementing agency of these surveys is usually the national statistical office (NSO). Most of these HCES have by now become multi-topic and multi-level surveys using several questionnaires to measure different aspects of living standards. While unique in their efforts to collect representative information on HHs' living standards, HCES might unintentionally undersample unregistered or vulnerable populations which are often excluded from the standard census on which HCES often rely for sampling. As a result, certain population groups might be inadvertently omitted or underrepresented from surveys including the homeless, internally displaced people, refugees, informal slum dwellers, or nomadic populations (e.g., Carr-Hill 2013; Lucci et al. 2018). While the *AHI* is bound by the available micro-level data, we undertake robustness checks, to account for this potential underrepresentation of e.g., slum areas in the HCES.

[7] A draft working paper is available from the authors on request.

In most HCES, the largest questionnaire is the HH questionnaire which collects detailed information on housing welfare and consumption. Demographic characteristics such as employment, education, health, gender, or age are collected at individual level. Most HCES, including living standard measurement surveys, household budget surveys, or household income and expenditure surveys also include a housing module, which covers a wide range of variables on housing conditions and physical characteristics of the housing unit such as the construction material used, the number of rooms the house has, or the availability of electricity. The module also collects information on housing-related expenditures such as utility bills or expenditures on maintenance and repairs. A complete list of surveys included in our analysis is displayed in Annex 2.

Despite the common focus on the determinants of consumption, expenditure, and living standards in developing countries, household consumption and expenditure surveys exhibit a diversity of structures and designs, with their own coding standards for variables, making cross-country comparison cumbersome. Given the specificities of each country, response options for variables within the housing module as well as standard questions on housing characteristics differ across regions and countries. While speaking to the same concept such as access to water or access to electricity, the way that concept is measured, which answer categories are provided, and how answers are coded across surveys might differ. In order to ensure comparability of housing adequacy across countries, the survey-specific variables on the seven adequacy dimensions need to be harmonized across HCES surveys.[8] We adopt harmonization practices followed by GMD and others in considering the harmonized adequacy dimension as a bivariate dummy at the household level on whether their response choices can be categorized as meeting adequacy criteria.

3.2.2 DHS

In order to complement and check the robustness of the coding and harmonization of the seven adequacy dimensions, we revert to Demographic and Health Surveys (DHS) which are nationally representative household surveys that provide data for a wide range of indicators in the areas of population, health, and nutrition and are primarily funded by the United States Agency for International Development (USAID). DHS collects multi-level information on characteristics of housing units and of residents, particularly focusing on demographic and health topics. Household questionnaires collect information on the housing unit such as the source of drinking water, toilet

[8] While there is significant effort at the World Bank Group to standardize surveys' variables into a global database that allows comparison across countries (GMD), this exercise is hitherto largely limited to variables pertaining to the reporting on measuring inequality, poverty, and welfare on a global scale. Across some regions, certain variables e.g., on WASH are also already unified in their answer categories. However, classification into adequate / inadequate housing conditions on these seven adequacy dimensions is hitherto absent.

facilities, cooking fuel, or assets of the household. Individual questionnaires record information on a range of health-related issues such as fertility, family planning, reproductive health, or nutrition. Data files follow a standardized format to maximize comparability across surveys. In contrast to HCES surveys, DHS does not collect information on HHs' income, consumption, or expenditure. The welfare variable that DHS provides is aggregated based on the various assets that HHs own (Rutstein 2015). [9]

3.2.3 Prindex

We also draw on Prindex data which offers comparable data on perceived tenure security – a variable usually unavailable in most multi-purpose surveys. Prindex is a joint initiative of the Overseas Development Institute (ODI) and Global Land Alliance (GLA), carrying out nationally representative surveys of adults in 140 countries measuring how secure individuals feel on their property. In addition, Prindex collects data on a range of demographic and socioeconomic characteristics of respondents, and on land-related variables that may influence the perception of tenure security such as documentation or ownership status. Prindex collects data at individual level and not at household level, therefore, aiming at capturing a fully representative and comparable assessment of individual perceptions on tenure security, not just the heads of households who are most likely to hold official titles.

We impute perceived tenure security reflected in Prindex into HCES based on three variables that are common across both surveys: income (quintiles), location (rural / urban), and ownership of the property (own / rent / other). In both surveys, we assign HHs into groups based on these three variables. We then include the average perceived tenure security of that group to the respective ownership variable available in HCES. As a result, we obtain a tenure security variable at household level that includes tenure perception provided by Prindex and ownership status provided by the most recent household consumption and expenditure survey. [10]

3.3 Summary Statistics of Adequacy Dimensions

This section explores housing adequacy at dimension level. Table 1 below provides summary statistics of the seven adequacy dimensions embedded in the *AHI*. Across all 64 economies, except for five countries, [11] all seven adequacy dimensions are available and harmonized across various variables according to the definitions provided in Section 3.1. The mean of each dimension

[9] For a concise overview on the calculation of the wealth quintile, consult https://dhsprogram.com/data/Guide-to-DHS-Statistics/Wealth_Quintiles.htm.

[10] As we are averaging perceived tenure security across income groups (HH level), rural / urban areas (country-level), and ownership status (HH level) in both data sets, the difference between the individual-level data that Prindex presents and the HH-level data of the HCES housing modules does not present an issue.

[11] Kazakhstan, Russian Federation, Ukraine, Uzbekistan, and Vietnam.

represents the proportion of households in the full estimation sample considered to be adequate. Pairwise correlations of the seven adequacy dimensions are reported in Annex 3.

Table 1: Summary Statistics of the Seven Adequacy Dimensions in 64 Economies

Adequacy Dimension	Number of Observations	Mean	Std. dev
Access to Water	2,461,605	.941	.235
Access to Sanitation	2,460,289	.575	.499
Adequate Living Space	2,395,203	.657	.475
Durable Material Good Structural Quality	2,145,454	.520	.519
Security of Tenure	2,453,341	.782	.109
Access to Electricity	2,463,409	.876	.330
Access to Clean Cooking	2,249,519	.443	.497

Note: Summary statistics of adequacy dimensions across 64 emerging economies. Missing data within countries are imputed as presented in section 3.4. Country specific statistics are presented in Annex 3.

Across the board, access to safe cooking fuel is most commonly absent in emerging economies' HHs. This is particularly acute in Sub-Saharan African economies, where the overarching majority of HHs does not have access to clean cooking and where HH air pollution stemming mostly from cooking smoke is a serious health hazard. This avoidable first-order public health crisis disproportionately harms women and children (cf. World Bank et al. 2014). Moreover, cooking with inadequate cooking fuels such as wood, charcoal, crop waste, dung, coal, or kerosene, also has a wide range of negative environmental and climate change effects.

Durable material is the second most deprived dimension in emerging economies. Only about 66 percent of housing units are built with durable material for roof, wall, or floor. The lowest are Botswana and the Democratic Republic of Congo, where mostly rudimentary or natural material are used.

For tenure security, about three-quarters of HHs feel insecure with the lowest perception of tenure security reported in Mali with only 28 percent of HHs feeling secure. It is key to point out that our operationalization of tenure security (by relying on HCES and Prindex data sources) measure perceptions of tenure security which might differ from *de facto* tenure security. Yet, perceptions influence behavior and investment decisions and bear key insights into the rather elusive concept of tenure security. Further, this standardized way of measurement allows for comparison across different tenure systems including those where customary titles or traditional forms of ownership may be more meaningful to HHs than legal documentation of rights. Further, this is hitherto the best possible data source on tenure security for a large set of countries (Prindex 2020).

Access to adequate water across emerging economies is highest across the seven adequacy dimensions followed by access to electricity. Yet, while substantial progress has been made in increasing access to clean drinking water within the last decade, many households, particularly in Sub-Saharan Africa and in rural areas still lack access. Access to water is lowest in Madagascar, where only 43 percent of HHs have access to adequate water.

3.4 Aggregating to the Adequate Housing Index

The *Adequate Housing Index* presents one unidimensional measure of housing adequacy. By harmonizing HCES variables and relying on one uniform definition of adequacy, the *AHI* offers a unique metric to compare housing adequacy within and across countries. Further, the *AHI* offers a summary picture of the multiple facets of housing adequacy, reduces complexity, and facilitates evaluation of housing adequacy. *AHI* also allows to rank countries according to their housing adequacy, monitor progress, and incentivize institutions and governments to revisit their standards in terms of housing adequacy. Rankings have become drivers of behavioral change and are consistently applied in a variety of areas (e.g., Kelley and Simmons 2015).

The aggregation of the underlying variables is the most important step within indicator creation. We construct the *Adequate Housing Index* for every household *i* in country *c* to estimate if that household lives in an adequate house

$$AHI_{i,c} = w_1 * a_{1i} + w_2 * a_{2i} + \ldots + w_7 \cdot a_{7i} \quad (1)$$

where $AHI_{i,c}$ is the adequate housing index for household *i* in country *c*, where (a_{1i}, a_{2i}, … , a_{7i}) are the seven housing adequacy dimensions of household *i* coded as dummy variables as discussed above, and where (w_1, w_2, … , w_7) are the respective weights assigned to each adequacy dimension and sum to one ($\sum_{i=1}^{7} w_i = 1$).

The *AHI* ranges between 0 (highly inadequate housing unit) and 1 (highly adequate housing unit). The aggregation of individual level *AHI* at the national or sub-national level can be interpreted as the share of the existing housing stock that is likely to be in adequate condition. Aggregating the seven adequacy dimensions into a unidimensional *AHI*, the principal determining factor is the weights to be assigned to each adequacy dimension. Weights assigned to the adequacy dimensions *a* are summarized by vector $w = (w1, \ldots, w7)$. We refer to this vector of weights as a weighting scheme. The aim of weights is to reflect the relative importance of each dimension or component to the index (Drewnowski 1974).

We apply an equal weighting scheme where all variables are given the same weight. Equal weighting is the most commonly applied weighting scheme in composite indices (Bandura 2008; OECD 2008). Examples include the Human Development Index, the Doing Business Index (World

Bank 2020b), financial benchmarks in the World Bank's Global Financial Development Database (Čihák et al. 2012), IMF's Index of Financial Development (Katsiaryna 2016), or the recently developed Fintech Activity Index (World Bank 2021).

Despite their intuitive interpretation, equal weighting schemes are also criticized for their normative assumptions and subjective judgements, oversimplification, and missing the point of differentiating between essential and non-essential dimensions (Greco et al. 2018; OECD 2008; Paruolo et al. 2013). However, as we discuss below, other aggregation methods also have drawbacks and we consider the assumption of equal weighting to be least problematic given the lack of information in the literature and priors that could guide alternate weighting schemes.

If propositions of many multilateral institutions such as the UN on how to estimate the housing deficit are taken in absolute terms (i.e., a housing unit can only be adequate if all adequacy dimensions are present at the same time), we obtain what we call the *strict Adequate Housing Index (sAHI*). The *sAHI* aggregates the adequacy dimensions based on the most lagging dimension and can be represented as a non-linear function:

$$sAHI_{i,c} = \min\{a_1 i,\ a_2 i\ \ldots\ a_7 i\} \tag{3}$$

This strict *AHI* considers an HH to live in inadequate housing if there is a deficiency on *any* of the seven dimensions. With this method, the most lagging dimension in terms of adequacy drives how many housing units are currently in need for adequate housing. Structural deficiencies which need to be addressed at regulatory level (e.g., improving tenure security through digitization of tenure records, etc.) drive the *sAHI*. While it has important implications for the realization of the Agenda 2030, the *sAHI* does not reflect the intensity of the inadequacy of housing (i.e., how many dimensions are deficient) and therefore might be too simplistic for practical applicability. Results reported in the remainder of this paper are, therefore, based on the *AHI* – if not otherwise explicitly stated as *strict Adequate Housing Index (sAHI)*. Comparisons of *sAHI* and *AHI* at country level can be found in Annex 4.

While the *AHI* offers an easy to interpret, unidimensional measure of housing adequacy that is comparable within and across countries, there are also several limitations. First, the *AHI,* by its nature, reduces complexity and hence also reduces information on the seven adequacy dimensions. Composite indices like the *AHI* are, therefore, often critiqued for only being able to convey "big picture" messages without being able to identify concreate policy actions (e.g., OECD 2008). Yet, while the *AHI* reduces the visible size of the seven adequacy dimensions, we clearly present the underlying information for further analytical work that can rely on such disaggregation. As housing adequacy is a multidimensional concept which cannot solely be captured by one of the adequacy dimensions such as access to water, the *AHI* provides a holistic and comprehensive

measure of housing adequacy. This unidimensional measure allows to assess the relative positions of emerging economies with regards to housing adequacy, provide an assessment of the general state of housing within a given economy, anticipate future developments and trends, and raise awareness regarding the overall housing situation within a given country.

Second, the soundness of the *AHI* is dependent on the *a priori* selection of its constituent variables and how they relate to the underlying concept of interest (in our case: housing adequacy) (e.g., Booysen 2002; Diener and Suh 1997; OECD 2008). In order to ensure cross-country comparability, the components of the index should be comprehensively capturing the phenomenon of interest, should be of universal significance, and should have cross-cultural applicability (Booysen 2002; OECD 2008). In our case, the selection of variables for the *AHI* was guided by theory as well as data availability and reliability. We selected seven adequacy dimensions that have consistently been found to be positively correlated with socio-economic development by a large body of research, that are outlined in the Agenda 2030 and are, therefore, of great political and practical relevance, and that are comparable across countries. The selection of dimensions was constrained by data availability in most recent HH surveys across a large set of countries and hence excludes variables on e.g., environmental security or location of the housing unit (more on this issue below).

Third, index creation is often critiqued for arbitrary weighting of its components (e.g., Cox et al. 1992; Foster et al. 2013; Nardo et al. 2005). One frequently cited issue associated with equal weighting schemes is "double counting" of conditions that are highly correlated. If two collinear dimensions are included into composite index, with a weight of w_1 and w_2, the unique dimension that the two indicators measure would have a weight of (w_1+ w_2) (cf. OECD 2008). We test the pairwise correlation of the seven adequacy dimensions, which although related, show low correlation (cf. Annex 3). Further, to internally validate the robustness and sensitivity of our assigned weights, we employ alternate weighting schemes to ensure that changes in the assigned weights will not have a significant impact on the *AHI* and the relative position of economies within the sample. In doing so, we test alternative weights obtained through principal component analysis (PCA), aggregating the seven adequacy dimensions into the $_{PCA}AHI$ considering their relative contribution to the total variance (detailed description of PCA and results in Annex 4). Lastly, we externally validate the index by correlating it with items (validators) not included in the index such as infant mortality and national income (Section 4.2).

3.5 Imputing Missing Data

Some economies' HH surveys do not have variables available on some of the seven adequacy dimensions. To still allow for a comprehensive *AHI* across all economies, we make use of

combined-sample imputation following Rendall et al. (2013). Initially, this technique was developed to correct for missing values on items from survey data. The method was expanded to cases where variables are not present by design because the question was not asked at all. To still allow for the same adequacy definition across the sample of 64 countries (all seven adequacy dimensions aggregated into *AHI*), we pool two nationally representative surveys (a) the countries HCES and (b) the respective Demographic and Health Survey (DHS) which both provide standardized information on a range of housing conditions to impute existing DHS data into HCES. We consider DHS as the "donor" survey and the HCES as the "recipient" survey. We take variables in common between the two data sets (i.e., location and wealth quintile of HH) to identify HHs with common characteristics in both samples to then impute on the *missing* dimension.

Two conditions must be satisfied for unbiased estimates (Rendall et al. 2013). First, the two pooled samples must be drawn from the same underlying population or "universe" (Carrig et al. 2015, Rendall et al. 2013; Rubin 1986). This assumption allows to treat the unobserved variable in the recipient survey as missing by design since the question has not been asked, which justifies the imputation across surveys (e.g., Gelman et al. 1998). Second, a number of variables must be "jointly observed" in both the donor and the recipient samples. Van Hook and colleagues (2015) demonstrate that the violation of the latter condition results in severe bias both in magnitude and direction.

For our purpose, both conditions are satisfied: Both DHS and HCES are nationally representative household surveys that collect a large range of variables on housing conditions. Further, location and household size are jointly observed in DHS and HCES. While DHS does not collect information on expenditure or income *per se*, the survey still calculates a wealth quintile based on other available data collected which are closely correlated with wealth.

Countries where DHS data were imputed include Albania (structural quality and cooking), Bangladesh (structural quality and cooking), Colombia (cooking), Ethiopia (structural quality), Indonesia (overcrowding), Nepal (structural quality), Pakistan (structural quality and cooking), Philippines (structural quality and cooking), and Senegal (cooking). For India and Mali, due to data quality issues in the HCES combined with rather old survey data (2011 and 2009 respectively), we reverted to DHS for all seven adequacy dimensions. For five countries (Kazakhstan, Russian Federation, Ukraine, Uzbekistan, and Vietnam) imputation was impossible due to missing data in both the HCES and DHS surveys and one dimension remains missing. Overall, this implies that we are potentially underestimating the inadequacy for those countries where data on one adequacy dimension is missing as a stricter definition of adequacy has shown to increase housing deficit estimations (cf. World Bank 2021).

3.6 Robustness of Adequacy Dimensions

We perform several robustness checks at dimensions level to test the robustness of our coding framework against macro-level data for all 64 emerging economies (Annex 6).

First, we compare the weighted survey average of each of the adequacy dimensions with the macro variable that best matches the adequacy concept. As the definitions of the seven adequacy dimensions for data available at macro-level and the respective HCES variables' definitions do not exactly match, some smaller deviations between macro-level data and weighted survey average are to be expected.

For WASH-related data, we compare the country averages obtained by coding access to water and access to sanitation obtained from HCES against macro-level data from JMP which is jointly managed by WHO and UNICEF. An alternative data source would be WDI, which classifies access to water by only considering "drinking water from an improved water source which is located on premises, available when needed and free from faecal and priority chemical contamination"; hence WDI does not capture water that is considered improved by JMP but located outside the HH's premises (e.g., Tubewells). For the robustness check on water, we therefore revert to JMP data and collapse the first three categories of the adequate drinking water ladder: safely managed, basic, and limited access to secure water.[12]

Further, we check our coding of the cooking and electricity dimension against macro data from the IEA, which has published databases on electricity access as well as on the reliance on traditional biomass for cooking since 2000 in their World Energy Outlook (WEO). [13]

As we combine PRINDEX data with the HCES ownership variable, we already implicitly include a macro-level variable for the tenure security dimension and therefore abstain from an additional macro-check.

To the best of our knowledge, there are no comparable data sets at macro-level for overcrowding and structural quality for a large enough sample. The results [*available in supplementary material*] show negligible differences which can likely be attributed to the differences in definition across surveys and macro-level data. Hence, we are comfortable that our harmonization efforts across the 64 household surveys measure the concept accurately.

[12] JMP provides an adequacy ladder of drinking water which includes safely managed drinking water located within the premises of the HH; basic drinking water, which is an improved source within 30 minutes roundtrip; and limited drinking water for which collection time exceeds 30 minutes. Since not all HCES data allow for the calculation of time to the nearest water source, we collapse these three categories of JMP for our robustness check instead of reverting to WDI data, which only includes the first category. For more information, see: washdata.org.

[13] https://www.iea.org/articles/defining-energy-access-2020-methodology

Second, we account for potential differences in survey years. While multi-purpose HH surveys are conducted every 3-5 years, some countries have dated surveys, including Iraq (2012), Madagascar (2012), or Senegal (2011). Since then, individual HHs might have improved on one or more of the seven adequacy dimensions. Yet, literature suggests that housing conditions are "sticky". For instance, according to the WEO, only seven million people in Sub-Saharan Africa have gained access to clean cooking since 2015 (IEA 2019). In order to test the "stickiness" for all housing conditions, we compare the *AHI* of the most recent survey year available in HCES to an adjusted *AHI* where we project every country's *AHI* to 2019 making use of available macro data discussed in the previous paragraphs. The results of this comparison are presented in Annex 6 along with the individual correlations of the four adequacy dimensions for which current macro-level data was available. Since the results exhibit great consistency of the housing conditions of the survey year and the most recently available macro-level year, we present the results of the *AHI* that uses the original survey year without any adjustments to current date.

4. Results: The *Adequate Housing Index* across and within Countries

The *AHI* provides the first micro-founded, comparative assessment of housing conditions. In the following sections we present the results for 64 emerging economies. The *AHI* can be disaggregated along several dimensions, allowing to draw a nuanced picture of housing adequacy within and across countries. The aggregate *AHI* represents the adequate housing deficit for each of these emerging economies. Since we are applying a global framework in denoting housing adequacy, the respective adequacy deficits – also if disaggregated – are comparable in magnitude within and between countries.

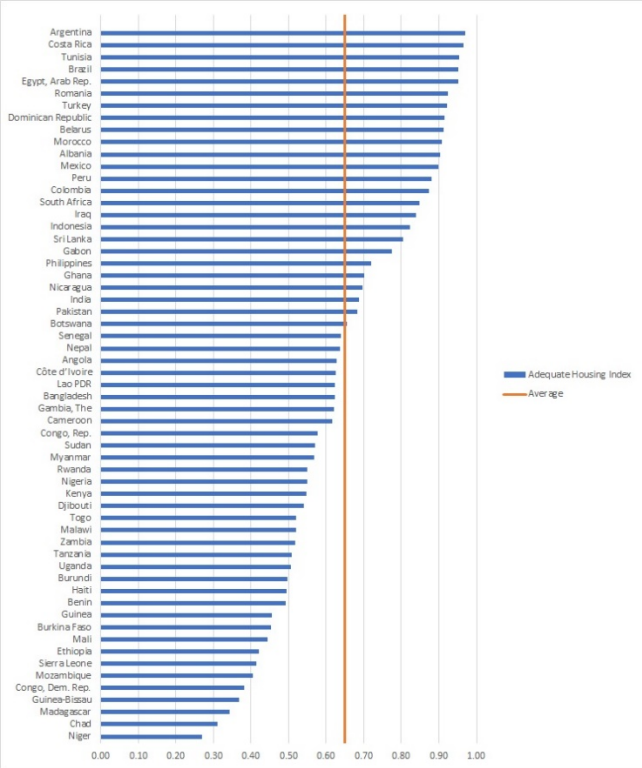
4.1 AHI – Housing Adequacy across Countries

Across the countries covered, there is a large variance in terms of adequate housing deficits (Figure 1). On average, about 68 percent of houses are adequate across emerging economies. However, there are stark differences between countries. Within the sample, Sub-Saharan African countries have the lowest *AHI* while countries in Europe & Central Asia as well as Latin America and the Caribbean have relatively high *AHI* scores. In Niger, Chad, and Madagascar up to 73 percent of the existing housing stock is likely to exhibit an adequate housing deficit. In comparison, Argentina's, and Costa Rica's current housing stock consists of largely adequate houses. The difference between Argentina respectively Costa Rica (both 0.97) and Niger (0.27) is significant and large. Comparing the *strict AHI* between these countries, a similar pattern emerges. In Costa Rica, 92 percent of houses are adequate on all seven adequacy dimensions, whereas in Niger virtually no house is adequate on all seven dimensions. In Niger, only about 53 percent of HHs have access to adequate water, 16 percent of HHs have access to improved sanitation, 2 percent of

HHs use clean cooking fuel, 15 percent of HH have access to electricity, 7 percent live in houses built with durable material, 23 percent of HH have adequate living space, and 73 percent of HH report to feel tenure secure (adequacy dimensions for all countries are presented in Annex 3).

In Brazil, the largest constraint to adequate housing is tenure security with about a quarter of HHs reporting to feel tenure insecure. This finding is in line with in-depth country studies showing that Brazilian HHs seem to be able to improve their overall housing conditions and gain access to urban services (sometimes through informal or negotiated means) even though they are in a situation of high tenure insecurity as they often acquired housing through informal or even illegal means (e.g., de Souza 2001; Hylton et al. 2018; Libertun de Duren & Osario 2020b).[14]

Figure 1: ***Adequate Housing Index*** **Compared Across Countries**

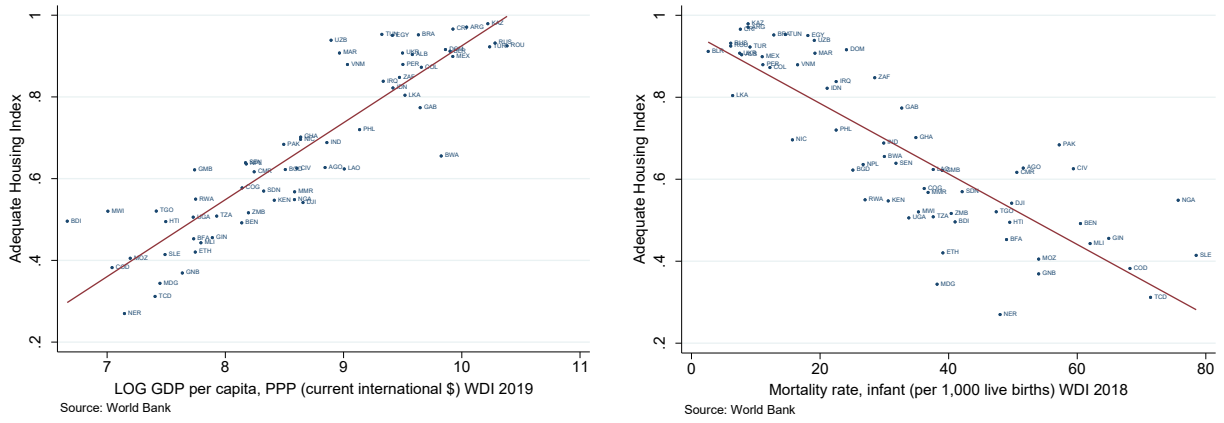


Note: *Adequate Housing Index*: Authors' calculation based on countries' latest available household consumption and expenditure survey. Note: the five countries with missing data on one of the AHI dimensions are omitted form this figure.

[14] The differentiation of uncertain land tenure where residents have some informal claim to the land but do not hold a legal title recognized by the state is crucial as the right to basic services like water or electricity is officially superseded by the obligation to have legal property rights (Guimarães et al. 2016).

As a simple way to understand the intuition behind the index and as a test of the validity of the index, we assess correlations of the country-level *AHI* with macro-level data using national income and infant mortality rate (Figure 2), variables that are not part of the index creation. The *AHI* is highly correlated with both concepts. The *AHI* is low in low-income countries, while higher- and middle-income countries exhibit higher scores on the *AHI*, consistent with the positive relationship established for the underlying dimensions of the AHI in the literature (cf. Section 3.2). Likewise, countries with a higher score on the *AHI* exhibit lower infant mortality rates. This provides evidence for external validity of the *AHI* as clear links have been established by literature on adequate housing conditions and health outcomes (e.g., Galiani et al. 2005; Jalan & Ravallion 2003; Nabassaga et al. 2019; Jamison et al. 1993). Ultimately, the *AHI* as well as data on the adequacy dimensions from this paper are meant to allow further research on such relationships.

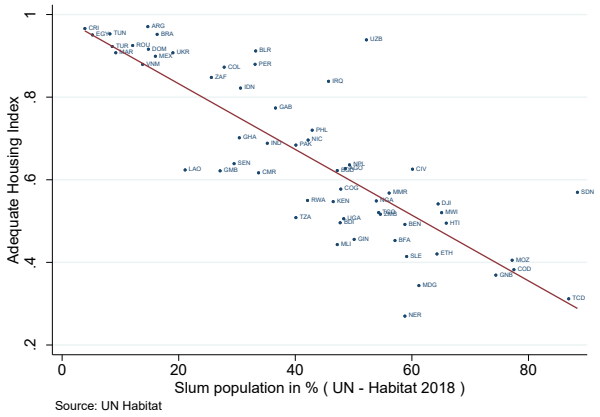
Figure 2: Correlation of *Adequate Housing Index* with GDP per capita and Infant Mortality



Note: Relationship between the *Adequate Housing Index* and GDP per capita (current international $) as well as child mortality per 1,000 live births. The correlation coefficient for *AHI* and GDP is .90; the correlation coefficient for *AHI* and infant mortality is -.83. (Source: Authors' calculation based on countries' latest available household consumption and expenditure survey, WDI 2018 / 2019 (GDP per capita, PPP) and WDI 2018 (Mortality rate, infant)).

In presenting national *AHI* figures, this paper relies heavily on the national representation of HCESs. As informal settlements or slum dwellers – HHs more likely to live in inadequate housing – might be inadvertently omitted from or underrepresented in these surveys (e.g., Carr-Hill 2013; Lucci et al. 2018), we assess the correlation between slum population and *AHI* (Figure 3). The correlation is strong and negative, providing suggestive evidence that at least at aggregate level, under-representation of slum population does not affect the cross-country interpretation of *AHI*.

Figure 3: ***Adequate Housing Index*** **and Slum Population**



Note: Relationship between the *Adequate Housing Index* and urban slum population. The correlation coefficient is - .83. (Source: Authors' calculation based on countries' latest available household consumption and expenditure survey and UN-Habitat 2018).

4.2 AHI – Within-Country Estimates

As the *AHI* is micro-founded it can be disaggregated along segments of the population within countries. In this section, we present disaggregated estimates of the *AHI* focused along several key dimensions.

4.2.1 AHI – Disaggregated by Household Income

In all 64 economies, adequate housing is often not delivered to the lower end of the income spectrum. With growing population and urbanization rates in the next decade, this issue will become even more acute. To reflect within-country differences in housing adequacy, we calculate the Gini coefficient of adequate housing per country, which reflects inequality in access to adequate housing (Table 2). The Gini coefficient is frequently applied in economic literature to assess the state of income inequality. Over time, the methodology for estimating the Gini coefficient has been extended beyond income and has been applied to measure the state of inequality in other areas such as education or human capital (Földvári & van Leeuwen 2011). In the housing literature, the Gini coefficient has been applied to the context of housing affordability (e.g., Ben-Shahar & Warszawski 2016; Buckley & Gurenko 1997; Landis et al. 2002). We propose and compute a Gini coefficient of housing adequacy based on the distribution of the *AHI*.

In many emerging economies, HHs earning below median income have a significantly lower likelihood to live in adequate housing. Niger exhibits the largest adequate housing inequality in emerging economies reflected in a housing adequacy (Gini coefficient of 0.39). In Niger's bottom half of the income spectrum, virtually every housing unit lives in an inadequate housing unit. Within the highest income decile, only 49 percent of HHs are likely to have access to adequate

housing. A similar pattern is observable the Democratic Republic of Congo, Madagascar, Mozambique, and Zambia where housing adequacy is also unequally distributed across top and bottom income groups. Even though the Democratic Republic of Congo enshrines the right to decent housing, access to drinking water as well as to electric energy in its 2006 Constitution (Art. 48), 62 percent of HHs in the Democratic Republic of Congo do not have access to adequate housing. This is most pronounced in the area of access to electricity: in the richest income decile only 70 percent of HHs have access to electricity and in the lowest income deciles less than 1 percent of HHs have access to electricity.

In countries such as Angola (housing adequacy Gini 0.25) and India (housing adequacy Gini of 0.19), the pattern is slightly different. In both countries, in the lowest income deciles, every third household is likely to live in an adequate house (about 36 percent). In the highest income decile, almost every HH (94 percent in India and 90 percent in Angola) is likely to have adequate housing. While the housing inadequacy is still very pronounced in the lowest income group, particularly compared to the richest HHs, housing adequacy gradually improves with growing incomes.

Iraq's access to adequate housing is rather equal across income deciles (housing adequacy Gini of 0.09). About 80 percent of low-income HHs and almost 90 percent of high-income HHs are likely to live in adequate housing. Iraq has a large water and sanitation network and almost all HHs according to the latest household survey have access to safe water (91 percent) and sanitation (99 percent) services. This closely ties in with the latest estimations by JMP, outlining that about 99 percent of households in Iraq have access to water and sanitation (UNICEF & WHO 2019). However, frequent power shortages, a continuing lack of qualified personnel, illegal water tapping, or failures to empty pit latrines contribute to system failures. For instance, while 40 percent of septic tanks and improved pit latrines are emptied on average in Iraq, there are great regional variances in emptying practices. Septic tanks and pit latrines are twice as likely to be emptied in South/Central Iraq compared to Kurdistan, ranging from 71 percent in Baghdad to 8 percent in Muthana (UNICEF & WHO 2019). The greatest constraint for adequate housing in Iraq is overcrowding. The average HH size in Iraq is seven people and large households with six or more members account for about half of all HHs. One person HHs are extremely rare in Iraq (less than 1 percent). On average, 3.7 HH members are sharing a room, with smaller regional disparities. In Baghdad, about 3.6 HH members are sharing a room, 4.4 in Maysan, 4.1 in Wasit and Najaf, 3.9 in Thi-qar, Anabr and Qadisiya, 3.8 in Basrah, 3.7 in Babylon and Kerbela, and 3.6 in Salah Al-Deen and Muthanna. The acute number of overcrowded houses in Iraq could point to the large number of internally displaced people (IDP) and numerous Iraqis who are returning from neighboring countries and are often finding shelter by host families as their houses were destroyed or seized. The number of IDPs and refugees, which often live in makeshift structures are

potentially under-sampled in Iraq's Integrated Household Socioeconomic Survey (IHSES) on which the *AHI* relies. To provide more frequent estimates, a Continuous Household Survey (CHS) was implemented in 2014 on a sub-sample of IHSES clusters. Given the large number of people displaced within the country since 2014, the survey was designed to capture a representative sample of internally displaced persons. However, the fieldwork was disrupted in the summer of 2014 in some parts of the country due to the deterioration in the security situation.

Table 2: *Adequate Housing Index* across Income Deciles

Country	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	AHI	Housing Gini
Albania	0.77	0.84	0.89	0.90	0.92	0.93	0.94	0.94	0.95	0.96	**0.90**	**0.05**
Angola	0.36	0.40	0.46	0.52	0.60	0.66	0.73	0.79	0.85	0.90	**0.63**	**0.25**
Argentina	0.94	0.95	0.97	0.98	0.98	0.98	0.97	0.97	0.99	0.99	**0.97**	**0.01**
Bangladesh	0.48	0.50	0.53	0.54	0.56	0.57	0.64	0.74	0.80	0.87	**0.62**	**0.16**
Belarus	0.85	0.88	0.90	0.91	0.91	0.92	0.93	0.94	0.94	0.95	**0.91**	**0.06**
Benin	0.40	0.41	0.46	0.45	0.47	0.49	0.51	0.52	0.57	0.64	**0.49**	**0.24**
Botswana	0.46	0.54	0.58	0.63	0.67	0.69	0.72	0.72	0.76	0.78	**0.66**	**0.16**
Brazil	0.91	0.94	0.94	0.94	0.96	0.96	0.96	0.96	0.97	0.98	**0.95**	**0.03**
Burkina Faso	0.32	0.33	0.37	0.38	0.44	0.47	0.47	0.52	0.55	0.69	**0.45**	**0.28**
Burundi	0.45	0.46	0.47	0.48	0.48	0.49	0.49	0.49	0.52	0.62	**0.50**	**0.16**
Cameroon	0.40	0.45	0.50	0.55	0.62	0.62	0.68	0.72	0.78	0.85	**0.62**	**0.21**
Chad	0.28	0.29	0.29	0.30	0.31	0.31	0.30	0.33	0.34	0.38	**0.31**	**0.23**
Colombia	0.71	0.79	0.85	0.87	0.88	0.89	0.91	0.92	0.94	0.95	**0.87**	**0.06**
Congo, Dem. Rep.	0.31	0.31	0.33	0.33	0.34	0.35	0.37	0.39	0.48	0.62	**0.38**	**0.23**
Congo, Rep.	0.37	0.43	0.48	0.52	0.55	0.60	0.66	0.67	0.72	0.78	**0.58**	**0.24**
Costa Rica	0.91	0.94	0.95	0.95	0.98	0.98	0.98	0.98	0.99	0.99	**0.97**	**0.02**
Côte d'Ivoire	0.51	0.53	0.55	0.56	0.61	0.64	0.63	0.68	0.74	0.81	**0.63**	**0.22**
Djibouti	0.28	0.34	0.44	0.48	0.58	0.62	0.65	0.66	0.67	0.70	**0.54**	**0.25**
Dominican Republic	0.84	0.89	0.90	0.91	0.91	0.93	0.93	0.94	0.95	0.96	**0.92**	**0.06**
Egypt, Arab Rep.	0.91	0.92	0.94	0.95	0.96	0.96	0.95	0.96	0.97	0.98	**0.95**	**0.03**
Ethiopia	0.41	0.41	0.39	0.40	0.40	0.41	0.41	0.42	0.43	0.53	**0.42**	**0.18**
Gabon	0.59	0.70	0.73	0.74	0.78	0.79	0.80	0.84	0.87	0.89	**0.77**	**0.15**
Gambia, The	0.57	0.56	0.58	0.60	0.60	0.62	0.62	0.66	0.68	0.74	**0.62**	**0.18**
Ghana	0.54	0.60	0.66	0.67	0.69	0.71	0.74	0.76	0.79	0.84	**0.70**	**0.19**
Guinea	0.33	0.35	0.37	0.39	0.44	0.44	0.49	0.54	0.56	0.64	**0.46**	**0.24**
Guinea-Bissau	0.34	0.34	0.34	0.34	0.36	0.37	0.39	0.39	0.39	0.42	**0.37**	**0.20**
Haiti	0.35	0.38	0.38	0.44	0.46	0.48	0.5`1	0.57	0.58	0.69	**0.49**	**0.23**
India	0.36	0.44	0.52	0.59	0.67	0.75	0.83	0.87	0.90	0.94	**0.69**	**0.19**
Indonesia	0.69	0.75	0.78	0.80	0.81	0.83	0.85	0.87	0.90	0.94	**0.82**	**0.13**
Iraq	0.79	0.81	0.83	0.83	0.83	0.83	0.85	0.86	0.87	0.88	**0.84**	**0.09**
Kazakhstan	0.98	0.98	0.98	0.98	0.97	0.97	0.98	0.98	0.98	0.98	**0.98**	**0.01**

Country	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	AHI	Housing Gini
Kenya	0.46	0.48	0.50	0.51	0.53	0.54	0.55	0.57	0.60	0.69	**0.55**	**0.20**
Lao PDR	0.52	0.54	0.58	0.59	0.62	0.62	0.65	0.67	0.70	0.75	**0.62**	**0.20**
Madagascar	0.26	0.25	0.27	0.27	0.27	0.29	0.34	0.39	0.48	0.63	**0.34**	**0.33**
Malawi	0.44	0.45	0.47	0.47	0.47	0.48	0.51	0.53	0.60	0.79	**0.52**	**0.17**
Mali	0.21	0.26	0.25	0.30	0.40	0.47	0.48	0.58	0.72	0.77	**0.44**	**0.27**
Mexico	0.78	0.84	0.86	0.88	0.91	0.92	0.93	0.94	0.95	0.96	**0.90**	**0.08**
Morocco	0.82	0.87	0.87	0.89	0.91	0.92	0.94	0.95	0.95	0.96	**0.91**	**0.06**
Mozambique	0.29	0.29	0.31	0.32	0.33	0.36	0.38	0.46	0.58	0.75	**0.41**	**0.29**
Myanmar	0.46	0.49	0.51	0.53	0.54	0.55	0.58	0.63	0.66	0.74	**0.57**	**0.20**
Nepal	0.50	0.53	0.52	0.55	0.58	0.60	0.68	0.73	0.82	0.86	**0.64**	**0.19**
Nicaragua	0.55	0.56	0.63	0.67	0.68	0.69	0.76	0.77	0.81	0.87	**0.70**	**0.15**
Niger	0.26	0.23	0.22	0.20	0.22	0.22	0.23	0.27	0.35	0.49	**0.27**	**0.39**
Nigeria	0.43	0.48	0.49	0.51	0.53	0.54	0.58	0.60	0.63	0.69	**0.55**	**0.20**
Pakistan	0.49	0.50	0.55	0.60	0.64	0.70	0.77	0.83	0.86	0.91	**0.68**	**0.15**
Peru	0.76	0.79	0.84	0.87	0.88	0.90	0.91	0.92	0.95	0.97	**0.88**	**0.10**
Philippines	0.49	0.53	0.59	0.65	0.70	0.75	0.81	0.85	0.89	0.93	**0.72**	**0.15**
Romania	0.88	0.91	0.91	0.91	0.93	0.93	0.94	0.94	0.94	0.96	**0.92**	**0.05**
Russian Federation	0.93	0.94	0.93	0.93	0.93	0.93	0.92	0.92	0.93	0.94	**0.93**	**0.07**
Rwanda	0.47	0.49	0.50	0.50	0.53	0.53	0.56	0.59	0.62	0.70	**0.55**	**0.14**
Senegal	0.51	0.51	0.52	0.59	0.56	0.65	0.69	0.74	0.78	0.86	**0.64**	**0.23**
Sierra Leone	0.39	0.39	0.37	0.38	0.38	0.40	0.42	0.43	0.47	0.52	**0.41**	**0.21**
South Africa	0.74	0.78	0.81	0.82	0.84	0.86	0.88	0.90	0.93	0.94	**0.85**	**0.09**
Sri Lanka	0.71	0.74	0.77	0.78	0.79	0.80	0.86	0.88	0.85	0.87	**0.80**	**0.09**
Sudan	0.43	0.48	0.53	0.56	0.57	0.58	0.61	0.62	0.63	0.70	**0.57**	**0.26**
Tanzania	0.37	0.40	0.42	0.44	0.47	0.50	0.54	0.57	0.64	0.74	**0.51**	**0.28**
Togo	0.35	0.39	0.46	0.45	0.50	0.53	0.58	0.60	0.66	0.68	**0.52**	**0.24**
Tunisia	0.90	0.93	0.95	0.95	0.96	0.96	0.96	0.96	0.98	0.98	**0.95**	**0.03**
Turkey	0.86	0.89	0.91	0.91	0.93	0.94	0.94	0.95	0.95	0.95	**0.92**	**0.04**
Uganda	0.39	0.41	0.43	0.45	0.48	0.51	0.52	0.55	0.60	0.71	**0.51**	**0.24**
Ukraine	0.81	0.86	0.89	0.90	0.90	0.93	0.94	0.95	0.94	0.95	**0.91**	**0.09**
Uzbekistan	0.92	0.93	0.94	0.95	0.94	0.95	0.94	0.95	0.94	0.93	**0.94**	**0.05**
Vietnam	0.75	0.79	0.82	0.84	0.88	0.90	0.93	0.95	0.96	0.96	**0.88**	**0.10**
Zambia	0.31	0.33	0.36	0.38	0.40	0.46	0.59	0.69	0.76	0.89	**0.52**	**0.28**

Note: *Adequate Housing Index* by income decile (Source: Authors' calculation based on countries' available household consumption and expenditure survey).

4.2.2 AHI – Disaggregated by Location, Gender, Education, and Occupation

Grouping HHs by age, education level, employment status, or location can also reveal key differences in housing adequacy. Within the sample, Brazil, India, Indonesia, and Nigeria are the most populous countries within their respective. To understand the *AHI* at the subnational level

for these four countries, we also compare adequate housing conditions across the three most populous cities or provinces (Table 3).

Table 3: *Adequate Housing Index* – Disaggregation along several dimensions[1]

	Location		Gender		Education*		Occupation		
Country	**Urban**	**Rural**	**Female**	**Male**	**Low**	**High**	**Agriculture**	**Industry**	**Services**
Albania	-	-	0.89	0.91	0.90	0.94	-	-	-
Angola	0.79	0.39	0.60	0.64	0.61	0.91	0.40	0.75	0.78
Argentina	0.97	-	0.97	0.97	0.97	0.97	0.94	0.97	0.97
Bangladesh[g]	0.70	0.59	0.63	0.62	0.61	0.80	0.56	0.63	0.65
Belarus	0.95	0.82	0.91	0.91	0.73	0.91	-	-	-
Benin	0.59	0.40	0.51	0.49	0.47	0.70	0.39	0.56	0.58
Botswana[g, o]	0.73	0.53	0.67	0.65	0.62	0.75	0.54	0.72	0.72
Brazil	0.96	0.91	0.95	0.95	0.94	0.96	0.92	0.95	0.96
Sao Paulo[g]	0.96	0.95	0.96	0.96	0.96	0.97	0.95	0.96	0.96
Rio de Janeiro[g]	0.96	0.95	0.96	0.96	0.96	0.97	0.95	0.96	0.96
Brasilia[g]	0.96	0.94	0.96	0.96	0.96	0.97	0.95	0.96	0.96
Burkina Faso	0.69	0.36	0.46	0.45	0.41	0.89	0.36	0.43	0.56
Burundi[g]	0.59	0.49	0.5	0.50	0.49	0.72	0.48	0.5	0.58
Cameroon[g]	0.79	0.48	0.62	0.61	0.59	0.85	0.44	0.69	0.73
Chad[g]	0.42	0.29	0.32	0.31	0.31	0.43	0.29	0.32	0.39
Colombia	0.91	0.74	0.88	0.87	0.85	0.94	0.75	0.89	0.91
Congo, Dem. Rep.[o]	0.49	0.32	0.39	0.38	0.36	0.53	0.33	0.42	0.44
Congo, Rep.	0.68	0.39	0.56	0.58	0.55	0.75	0.39	0.63	0.67
Costa Rica[g]	0.97	0.94	0.97	0.97	0.96	0.99	0.94	0.97	0.98
Côte d'Ivoire	0.73	0.49	0.67	0.62	0.61	0.87	0.49	0.7	0.74
Djibouti[g]	0.60	0.31	0.55	0.54	0.53	0.69	-	-	-
Dominican Republic	0.93	0.87	0.93	0.91	0.91	0.95	0.83	0.91	0.93
Egypt, Arab Rep.	0.96	0.94	0.94	0.95	0.95	0.97	0.93	0.95	0.96
Ethiopia	0.56	0.38	0.45	0.41	0.41	0.49	0.37	0.50	0.53
Gabon	0.81	0.62	0.77	0.77	0.76	0.87	0.60	0.78	0.81
Gambia, The	0.69	0.51	0.67	0.61	0.61	0.75	-	-	-
Ghana	0.78	0.60	0.71	0.70	0.68	0.85	0.56	0.74	0.77
Guinea	0.67	0.36	0.51	0.45	0.44	0.68	-	-	-
Guinea-Bissau[g]	0.39	0.36	0.37	0.37	0.37	0.48	-	-	-
Haiti	0.58	0.41	0.51	0.48	0.47	0.70	-	-	-
India	0.84	0.61	0.69	0.68	0.67	0.87	-	-	-
Delhi	0.88	-	0.85	0.89	0.86	0.95	-	-	-
Mumbai[g]	0.84	-	0.85	0.83	0.83	0.88	-	-	-
Bangalore [l]	0.89	0.87	0.90	0.88	0.87	0.93	-	-	-
Indonesia	0.88	0.76	0.80	0.83	0.82	0.91	0.73	0.86	0.88
West Java	0.90	0.80	0.84	0.87	0.84	0.92	0.78	0.88	0.90
East Java	0.90	0.80	0.82	0.85	0.82	0.92	0.78	0.87	0.90
Central Java	0.88	0.80	0.81	0.85	0.82	0.90	0.78	0.86	0.89
Iraq	0.86	0.77	0.87	0.83	0.83	0.89	0.76	0.83	0.85
Kazakhstan[e]	0.97	0.99	0.98	0.98	0.98	0.98	-	-	-
Kenya	0.65	0.47	0.53	0.55	0.51	0.72	-	-	-

	Location		Gender		Education*		Occupation		
Country	**Urban**	**Rural**	**Female**	**Male**	**Low**	**High**	**Agriculture**	**Industry**	**Services**
Lao PDR	0.75	0.57	0.69	0.62	0.61	0.74	0.57	0.69	0.76
Madagascar	0.51	0.31	0.36	0.34	0.25	0.38	0.24	0.42	0.50
Malawi	0.66	0.49	0.50	0.53	0.51	0.69	0.53	0.61	0.69
Mali[g]	0.67	0.38	0.44	0.44	0.43	0.72	-	-	-
Mexico	0.93	0.78	0.91	0.90	0.88	0.96	0.75	0.91	0.93
Morocco	0.94	0.85	0.92	0.91	0.90	0.95	0.84	0.90	0.93
Mozambique	0.62	0.30	0.43	0.40	0.39	0.57	0.31	0.51	0.59
Myanmar	0.73	0.51	0.61	0.56	0.56	0.60	0.49	0.57	0.65
Nepal[g]	0.79	0.59	0.63	0.64	0.63	0.88	0.50	0.60	0.76
Nicaragua	0.83	0.51	0.76	0.67	0.67	0.86	0.49	0.75	0.82
Niger	0.57	0.21	0.33	0.26	0.26	0.73	0.21	0.42	0.52
Nigeria[o]	0.65	0.48	0.58	0.54	0.51	0.60	0.61	0.63	0.65
Kano[g,l,e,o]	0.51	0.47	0.54	0.47	0.36	0.58	-	0.34	0.55
Lagos[e,o]	0.70	0.60	0.73	0.70	0.60	0.79	-	0.67	0.74
Kadua[g,o]	0.60	0.43	0.52	0.51	0.40	0.55	0.70	0.57	0.66
Pakistan	0.79	0.62	0.69	0.68	0.66	0.84	0.60	0.66	0.73
Peru	0.92	0.74	0.89	0.87	0.86	0.94	0.77	0.91	0.92
Philippines	0.78	0.67	0.75	0.71	0.70	0.88	0.61	0.72	0.77
Romania	0.96	0.89	0.92	0.93	0.91	0.98	-	-	-
Russian Federation[l,g]	0.93	0.94	0.93	0.93	0.93	0.93	-	-	-
Rwanda	0.66	0.52	0.53	0.56	0.54	0.76	0.52	0.56	0.62
Senegal	0.77	0.51	0.73	0.61	0.63	0.81	-	-	-
Sierra Leone[o]	0.51	0.35	0.42	0.41	0.40	0.52	0.35	0.46	0.48
South Africa	0.88	0.79	0.84	0.86	0.83	0.92	-	-	-
Sri Lanka[g]	0.86	0.79	0.80	0.80	0.80	0.91	0.75	0.80	0.84
Sudan[o]	0.70	0.50	0.55	0.57	0.63	0.51	0.45	0.65	0.66
Tanzania[g]	0.71	0.40	0.52	0.50	0.49	0.81	0.41	0.61	0.70
Togo[g]	0.70	0.36	0.53	0.52	0.50	0.80	0.38	0.59	0.64
Tunisia	0.97	0.92	0.95	0.95	0.96	0.95	0.93	0.95	0.96
Turkey[o]	-	-	0.91	0.92	0.92	0.94	0.88	0.93	0.93
Uganda	0.67	0.44	0.52	0.50	0.48	0.71	0.41	0.55	0.63
Ukraine	0.95	0.82	-	-	-	-	-	-	-
Uzbekistan	0.97	0.93	0.95	0.94	0.93	0.96	-	-	-
Vietnam	0.94	0.85	0.89	0.87	0.88	0.86	0.81	0.91	0.93
Zambia	0.71	0.37	0.50	0.52	0.48	0.59	0.36	0.67	0.71

[1] All differences are significant (at least) at 95 percent level except for countries marked as follows:
[l] Location dimension; [e] Education dimension, [g] Gender dimension; [o] Occupation dimension (industry / services)

Note: *Adequate Housing Index* disaggregated along several dimensions (Source: authors' calculation based on countries' available household consumption and expenditure survey). *Low education refers to household heads with at most secondary education completed, while high education refers to household heads with more than secondary education. – refers to respective disaggregation unavailable in the countries' latest HCES survey.

The most striking difference in housing adequacy can be observed between rural and urban areas which is prominent across all countries. The difference is largest in Angola and Niger, with 40 percentage points difference in Angola and 36 percentage points difference in Niger between rural and urban areas regarding HHs likely to live in adequate housing. In urban Angola, about 79 percent of households are likely to be adequate compared to only 39 percent in rural area. The difference between rural and urban areas is rather low in countries with already high *AHI* like the Arab Republic of Egypt (2 percentage points) or Costa Rica (3 percentage points) (cf. Annex 6 on the *AHI* and urbanization rates). Within Angola, there is large variation across regions. In the capital Luanda, most housing units (88 percent) are likely to be adequate. The next best region is Cabinda (79 percent) followed by Namibe (69 percent). The region with the lowest likelihood for adequate housing is Cunene (42 percent) followed by Huíla (46 percent).[15] In Niger, a similar picture emerges. The biggest business city and capital, Niamey (64 percent), has a much greater likelihood for adequate housing compared to the rest of the country. The next best region is Agadez (33 percent) in the central part of the country. The region with the least likelihood of adequate housing is Tillabéri (23 percent) followed by Maradi (23 percent) which is almost half of the adequacy likelihood of the capital city.[16] However, this difference does not translate when we compare the HHs by income within the region. The poorest HH in Niamey is more likely to live in adequate housing (38 percent) compared to the richest HH in Tillabéri (32 percent), the region with the lowest overall housing adequacy.

The difference on the *Adequate Housing Index* between female- and male-headed households is less pronounced across most countries with some notable exceptions (Nicaragua; Senegal). In Nicaragua, female-headed households are more likely to live in adequate housing conditions. Particularly in terms of access to clean cooking fuels and electricity, the difference is more than 15 percentage points between male-headed and female-headed HHs. Similarly, in Senegal, female-headed HHs are significantly more likely to be adequate than male-headed HHs; the difference is stark: 73 percent of female-headed HHs are likely to live in adequate housing as opposed to 61 percent of male-headed HHs. The difference is particularly striking in higher income deciles: male-headed households in Senegal's highest income decile have a likelihood of 84 percent to live in an adequate house. In contrast, Senegal's richest female-headed HHs have a 91 percent likelihood for adequate housing. The difference is also spark in the first three income deciles where female-headed HHs are almost 10 percentage points more likely to be adequate than male-headed HHs.

[15] Other regions' likelihood for adequate housing include Uíge (0.46), Cuanza Sul (0.46), Bié (0.47), Móxico (0.48), Lunda Norte (0.49), Cuando Cubango (0.49), Lunda Sul (0.55), Malanje (0.55), Huambo (0.57), Cuanza Norte (0.57), Bengo (0.62), Zaire (0.64), and Benguela (0.66).

[16] Other regions' likelihood for adequate housing include Zinder (0.26), Diffa (0.25), Tahoua (0.24) and Dosso (0.23).

Consistent with other studies, adequate housing seems to be a higher priority for female-headed HH, particularly if incomes rise beyond the median income (e.g., UN-Habitat 2014). Female-headed households may also be more likely to use their house as an informal business, a contributing factor explaining their better housing adequacy outcome.

Next, we disaggregate by education of the head of household.[17] Within the sample of 64 emerging economies, the difference in terms of housing adequacy between high educated and low educated HHs is most pronounced in Burkina Faso, where 89 percent of educated HHs have adequate housing compared to only 41 percent of HHs with heads having below secondary education. Burkina Faso HHs with low educated HH heads have a 40 percent likelihood to live in adequate housing.

We also find housing adequacy to vary by occupation of the head of HH. HHs where HH heads are employed in the agriculture sector are significantly more likely to have inadequate housing compared to their peers in the services or industry sector.[18] The difference between employees in the agriculture sector – a highly informal sector – and the service sector is most pronounced in Angola, Zambia, and Nicaragua.

Differences in terms of likelihood for adequate housing are also observable within the three biggest cities / provinces in Brazil, India, Indonesia, and Nigeria. Differences are most pronounced in Nigeria. Overall, only about 55 percent of HHs live in adequate housing conditions. About 87 million people in Nigeria live in inadequate housing. Within Nigeria's three biggest cities, 7 million people in Kano, 3.8 million in Lagos, and 4 million in Kadua live in inadequate housing conditions. In contrast, in Brazil, there are almost no differences between the three largest cities. Overall, about 10 million people across the country are currently in need for adequate housing. Brazil's HH survey is one of the few surveys that provides information on ethnic origin. The difference between indigenous groups, Afro-Americans, and others is small but significant. Indigenous peoples are less likely to live in adequate housing (93 percent), compared to Afro-American peoples (95 percent) and Whites (95 percent).

5. Estimating the Stock and Flow Housing Deficit

The main issue in developing an empirical estimate of the housing deficit is conceptualizing what a stock or flow housing deficit precisely encompasses. The computation of the *AHI* presents the

[17] Research has shown that adequate housing is strongly associated with better educational outcomes, particularly in children as it is associated with lower numbers of disruptive moves, evictions, or crime (e.g., WHO 2018). Yet, the direction of the association can also be reverse: education of HH heads can also have an impact on housing adequacy as more educated HHs might place higher importance to adequate housing conditions, or as more educated HHs might have more financial means or information to access housing finance.

[18] This may also reflect that HHs employed in the agriculture sector are more likely to live in rural areas.

conceptual underpinning to estimate housing deficit focused on inadequacy of housing across and within countries. Therefore, the estimation of the housing deficit presented in this section frames the challenge faced by households in securing housing that is adequate. We present the estimates of housing deficit in terms of number of housing units based on the *AHI*, average HH size, and the country's current population. This presentation of the deficit as the number of housing units offers practical applicability for policy makers drafting housing policies or planning subsidy programs for lower-income segments as well as private sector companies along the housing value chain. We refer to this number as the adequate housing *stock deficit*. This deficit can be tackled by not only building new housing units but also by expanding infrastructure networks to reach all segments of the population, by providing consistent services to all aspects of housing adequacy, as well as by upgrading or replacing inadequate housing. Although our data does not allow to fully distinguish these two aspects contributing to the overall stock deficit, we present an indicative estimate of the subset of the deficit that may require new or replacement buildings, as opposed to just upgrade and refurbishments. Based on the stock assessment, under assumptions of continuation of business-as-usual policies and practices, and using projection of urbanization rates and population growth, we also estimate the *flow deficit*, which is the projected housing deficit by 2030.

5.1 Stock Deficit

Making use of the *AHI's* interpretation at the aggregate level as the share of housing that is inadequate, we estimate the current stock deficit, defined here as the difference between the projected number of housing units in a country and those units that are currently inadequate. We approximate the number of current housing stock by drawing on available data of countries rural and urban population as well average HH size in rural and urban areas.[19] Based on these estimations, we estimate a country's current housing stock deficit as

$$D_c = [(1\text{-}AHI_{u,c})\ S_{u,c}\ P_{u,c}] + [(1\text{-}AHI_{r,c})\ S_{r,c}\ P_{r,c}] \quad (4)$$

where D is the current housing stock deficit for country c, $AHI_{u,c}$ is the *urban* Adequate Housing Index, $AHI_{r,c}$ the *rural* Adequate Housing Index, $S_{u,c}$ the average urban household size, $S_{r,c}$ the average rural household size, $P_{u,c}$ the current urban population, and $P_{r,c}$ the current rural population.

The overall housing deficit across emerging economies is denoted as the sum of the countries' housing stock deficits (Table 4). Based on this calculation, we estimate that the housing deficit in emerging markets affects at least 268 million households or about 1.26 billion people. Across 64 emerging economies, about 26 percent of the current stock of housing units is inadequate.

[19] We do not draw a distinction between number of households and number of housing units/dwellings. The latter data is available through HOFINET for only a small sample of countries. For these countries, the number of dwellings is approximated closely by the number of estimated households we use.

The largest absolute housing deficit is observed in India at over 89 million housing units. About 73 million houses are inadequate in rural India, compared to 16 million in urban areas. The smallest absolute housing deficit is observed in the smallest country in the sample, Costa Rica, at about 50,000 housing units. At per capita level, the largest housing deficit is observed in Botswana with 0.16 housing units estimated to be inadequate, followed by Madagascar (0.14) and Ethiopia (0.13). In comparison, India's per capita deficit denotes 0.07 housing units (refer to Annex 7 for countries' urban and rural housing deficits).

Nigeria, Brazil, Pakistan, Indonesia, and India, the five most populous countries in the sample have a cumulative adequate housing deficit of about 132 million housing units. Among those, 34 million housing units are inadequate in urban areas and 98 million units in rural areas. Hence, these five countries account for about 49 percent of the housing deficit in the sample. In Nigeria, about 15.56 million housing units are currently inadequate, affecting about 87 million people. Given its size, Brazil's adequacy stock deficit is comparatively small (3.43 million), with only 0.02 housing units estimated to be inadequate per person. In contrast to most other countries, the adequate housing stock deficit in urban Brazil is higher (2.6 million) than in rural Brazil (0.8 million). Likewise, in the Russian Federation, the urban housing deficit (2.47 million housing units) is three times the size of the rural housing deficit.

Rwanda's housing deficit, a country which has 5 percent of Brazil's population, has a comparable absolute number of inadequate housing units (1.32 million), which amounts to 0.10 inadequate housing units per capita. Sub-Saharan African countries in the sample, which constitute about 95 percent of Sub-Saharan Africa's population, have a cumulative stock deficit of about 97 million units. Hence, 37 percent of the housing deficit in the sample is accounted for by Sub-Saharan African countries.

An important consideration for the stock housing deficit is understanding the distinction between deficits arising among HHs whose housing units can be upgraded through the provision of infrastructure (e.g., water or sanitation services) or which can be refurbished or repaired (e.g., upgrading building material; better roofing etc.) from those HHs that may need an entirely new housing unit to overcome inadequacies. Although both aspects on inadequacy contribute to the housing deficit, they propose entirely different implications for policy makers and other stakeholders. Our data does not allow us to fully distinguish these two aspects contributing to the overall deficit. For example, consistent data on co-habitation and the number of households sharing the same dwelling are absent in HCESs. Nevertheless, to better understand the scale of the proportion of the deficit requiring new building construction, we assess the prevalence of severe over-crowdedness along the dimension of adequacy of living space in the AHI. In doing so, we assume that this dimension is most closely linked with co-habitation, and given data challenges,

can provide a *lower bound* on the fraction of the deficit where repairs or refurbishments would not suffice to make that household adequate.

We approximate this lower bound by following a similar approach as the stock deficit estimation above. We first estimate share of housing units that are severely overcrowded, separately in urban and rural areas (cf. Equation 4). We then use this fraction to estimate the subset of the stock urban and rural deficits respectively that are deficient due to severe over-crowdedness:

$$U_c = [\ (1-A_{o,u})*D_{c,u}] + [\ (1-A_{o,r})*D_{u,r}] \quad (5)$$

where U_c is the number of *current* housing units in country *c* that need to be built anew since upgrading, repairs, or refurbishment would not suffice to address the housing deficit, $A_{o,u}$ is country's *c* average living space adequacy in urban areas and $A_{o,r}$ the average living space adequacy in rural areas, $D_{c,u}$ the housing deficit in urban areas and $D_{u,r}$ the housing deficit in rural areas.

Based on this calculation, we estimate the current number of houses that may need to be built anew right now based on *just one measure* to be *at least* 68 million. This is equivalent to about 25 percent of the overall housing stock deficit. Despite the lack of data to distinguish the two aspects of the deficit more precisely, this estimation does provide suggestive evidence of the significant fraction of the deficit that may only be addressed by building new housing units. Upgrading or repairs will not suffice to address a large proportion of the housing deficit.

This is particularly acute in Niger, where about 79 percent of the existing housing stock deficit will have to be addressed by building entire new housing units as opposed to refurbishing or repairing existing ones (cf. Annex 8). Similarly, in Iraq, about 53 percent of the existing housing stock has to be addressed by building new houses. As outlined above, this is due to the acute number of overcrowded houses in Iraq which is probably a reflection of the large number of internally displaced people (IDP) and numerous Iraqis who are returning from neighboring countries and are often finding shelter by host families as their houses were destroyed or seized.

Table 4: ***Stock & Flow Deficit*** **– AHI and the Number of Inadequate Housing Units**

			Stock Deficit – 2019		Flow Deficit - 2030
Country	**AHI– National Average**	**Households (in million)**	**Inadequate Housing Units (in million)**	**Inadequate Housing Units per capita**	**Inadequate Housing Units projected to 2030 (in million)**
Albania*	0.90	0.78	0.08	0.03	0.07
Angola	0.63	6.30	2.21	0.07	2.88
Argentina*	0.97	13.62	0.40	0.01	0.44
Bangladesh	0.62	40.37	14.79	0.09	15.89
Belarus	0.91	3.87	0.31	0.03	0.28
Benin	0.49	2.80	1.41	0.12	1.83
Botswana	0.66	1.12	0.38	0.16	0.43
Brazil	0.95	72.36	3.43	0.02	3.56
Burkina Faso	0.45	2.83	1.46	0.07	1.91
Burundi	0.50	2.40	1.20	0.10	1.63
Cameroon	0.62	5.94	1.97	0.08	2.45
Chad	0.31	2.85	1.94	0.12	2.63
Colombia	0.87	15.14	1.83	0.04	1.87
Congo, Dem. Rep.	0.38	17.23	10.46	0.12	14.09
Congo, Rep.	0.58	1.26	0.53	0.10	0.67
Costa Rica	0.97	1.58	0.05	0.01	0.05
Côte d'Ivoire	0.63	7.27	2.85	0.11	3.60
Djibouti	0.54	0.19	0.09	0.10	0.10
Dominican Republic	0.92	3.45	0.29	0.03	0.30
Egypt, Arab Rep.	0.95	24.09	1.19	0.01	1.42
Ethiopia	0.42	24.47	14.07	0.13	18.14
Gabon	0.77	0.56	0.12	0.05	0.14
Gambia, The	0.62	0.35	0.13	0.05	0.17
Ghana	0.70	8.06	2.32	0.08	2.80
Guinea	0.46	1.98	1.05	0.08	1.36
Guinea-Bissau	0.37	0.23	0.15	0.08	0.19
Haiti	0.49	2.35	1.16	0.10	1.27
India	0.69	291.60	89.88	0.07	95.01
Indonesia	0.82	73.38	12.62	0.05	13.26
Iraq	0.84	5.86	0.94	0.02	1.19
Kazakhstan	0.98	5.42	0.11	0.01	0.13
Kenya	0.55	12.85	6.03	0.11	7.58
Lao PDR	0.62	1.39	0.51	0.07	0.56
Madagascar	0.34	6.16	3.77	0.14	4.91
Malawi	0.52	4.34	2.09	0.11	2.76
Mali	0.44	3.31	1.66	0.08	2.16
Mexico	0.90	35.57	3.35	0.03	3.54

			Stock Deficit – 2019		Flow Deficit - 2030
Country	**AHI– National Average**	**Households (in million)**	**Inadequate Housing Units (in million)**	**Inadequate Housing Units per capita**	**Inadequate Housing Units projected to 2030 (in million)**
Morocco	0.91	7.69	0.69	0.02	0.74
Mozambique	0.41	4.85	2.82	0.09	3.69
Myanmar	0.57	11.93	5.07	0.09	5.37
Nepal	0.64	5.90	2.14	0.07	2.43
Nicaragua	0.70	1.50	0.44	0.07	0.48
Niger	0.27	3.56	2.59	0.11	3.84
Nigeria	0.55	36.63	15.56	0.08	20.00
Pakistan	0.68	34.55	10.81	0.05	12.90
Peru	0.88	9.11	1.10	0.03	1.17
Philippines	0.72	23.42	6.47	0.06	7.30
Romania	0.92	7.34	0.53	0.03	0.49
Russian Federation	0.93	54.08	3.69	0.03	3.64
Rwanda	0.55	2.92	1.32	0.10	1.68
Senegal	0.64	1.81	0.63	0.04	0.82
Sierra Leone	0.41	1.40	0.81	0.10	0.99
South Africa	0.85	15.28	2.29	0.04	2.53
Sri Lanka	0.80	5.73	1.12	0.05	1.14
Sudan	0.57	6.28	2.70	0.06	3.41
Tanzania	0.51	12.55	6.06	0.10	7.92
Togo	0.52	1.69	0.81	0.10	1.01
Tunisia	0.95	2.91	0.14	0.01	0.14
Turkey*	0.92	24.68	1.91	0.02	2.04
Uganda	0.51	9.98	4.93	0.11	6.49
Ukraine	0.91	17.22	1.52	0.03	1.37
Uzbekistan	0.94	7.06	0.35	0.01	0.39
Vietnam	0.88	25.40	3.00	0.03	3.03
Zambia	0.52	3.48	1.65	0.09	2.15

Note: Number of inadequate households extrapolated from the AHI, average HH size, and overall number of population (Source: Authors' calculation based on countries' available household consumption and expenditure survey and WDI (2019)). * Due to absence of rural / urban differentiation in HCES, stock deficits are calculated based on overall AHI, total population, and total average HH size for these countries.

5.2 Flow Deficit

Given unprecedented population growth rates that are projected to add millions of people by 2030, many more additional HHs will require adequate housing within the next decade. Based on projected urbanization rate and population growth, we estimate that at least 40 million *additional*

housing units would have to be built to reach target 11.1 of the sustainable development agenda by 2030. This estimation assumes that governments do not put in place ambitious programs to upgrade existing inadequate housing, improve service delivery, refurbish existing units, and build new adequate housing units. In order to provide adequate housing by 2030, four million *additional* adequate housing units would be required every year.

Given the expected migration to urban areas, we differentiate the flow deficit by urban and rural areas. By 2030, within the sample, at least 103 million urban HHs[20] and 202 million rural HHs are projected to live in inadequate housing units if governments and private sector participants continue on business-as-usual policies and practices without further addressing the already existing housing deficits.

Within the sample, India, given its predicted population growth in both rural and urban areas is expected to have the largest adequate housing deficit. In urban areas, India is responsible for the lion's share (31 percent) of the overall adequate housing deficit in the sample, with 21.6 million urban housing units predicted to be inadequate by 2030. The second largest adequate housing deficit in urban areas is projected for Nigeria (10 million inadequate housing units in 2030). In Bangladesh, the adequate housing deficit in urban areas is projected to be 6.2 million by 2030, followed by the Indonesia (5.9 million by 2030 given the predicted population growth in urban areas). The five countries with the largest predicted urban population by 2030 (India, Brazil, Indonesia, Nigeria, Mexico) are likely to have a cumulative adequate housing deficit of 43.4 million housing units in urban areas.

In rural areas, the three countries with the largest predicted adequate housing deficit include India (73.3 million), Ethiopia (13.4 million), and Bangladesh (9.6 million). Together, these three countries account for about 48 percent of the overall predicted adequate housing deficit in rural areas in the sample. The five countries with the largest forecasted rural population by 2030 (India, Pakistan, Indonesia, Nigeria, and Ethiopia) are likely to have a cumulative adequate housing deficit of 112.9 million housing units.

6. Conclusion

In this paper, we introduce a new *Adequate Housing Index*, which allows for a micro-founded comparison of housing adequacy across 64 emerging economies. To the best of our knowledge, this is the first paper to present cross-country microdata pooled from household surveys on housing conditions on a series of countries across different income groups and continents.

[20] Due to the absence of location marker in Albania's and Turkey's HCES, urban estimations are excluded here.

We find that many emerging economies have large deficits in terms of housing adequacy already today. Across the 64 countries in the sample, we estimate that about 26 percent of HHs, comprising a total of 268 million housing units, currently live in inadequate housing. This number is projected to grow by more than 40 million units until 2030 if governments and private sector actors along the housing value chain are not able to act swiftly. The poorest countries face the direst housing deficits in both housing stock and flow.

With this paper, at a more disaggregated level, we show that housing conditions correlate highly with income level of HHs. Yet, inadequacy of housing is not only confined to low-and lower-middle income HHs. Middle and upper-middle income HHs often also live in inadequate housing conditions, especially in low and lower-middle income countries. This vividly shows that efforts to address the adequate housing gap need to take the specific needs of different segments of the population into consideration in order to cater housing interventions appropriately. The results of the paper suggest that the income group requiring external interventions by governments and development finance institutions does not necessarily comprise only the lower income segment. Disaggregated within-country analysis along income and other dimensions such as gender or location could be a basis for tailoring external interventions. As the prevalence of inadequate housing seems to be disproportionally affecting low-income countries, particularly in Sub-Saharan Africa, addressing the adequate housing deficit is imminent to enhance economic growth and mitigate income disparities.

A further challenge is that, even in countries where the right to adequate housing is enshrined in the constitution or ordinary legislation, poor or rural families, uneducated HHs, workers in the agriculture sector, ethnic minorities, or other disadvantaged groups are often unable to exercise that right. According to our estimations, these groups are significantly more likely to find themselves in inadequate, low-quality housing with minimal access to improved facilities. Future research needs to investigate why that is the case.

Our results also indicate that countries need to be more innovative in providing adequate housing to everyone – particularly to vulnerable groups. Creative approaches in housing finance to improve existing housing stock, unlocking land supply, and inclusive urban planning will be required to provide adequate housing to all segments of the current population and the 1.6 billion people who will be added to urban areas by 2030.

The cross-country nature of the analysis and the reliance on household surveys entails several caveats. While household surveys provide a great source of micro-level data, they are expensive to execute and are only available for certain years. As of now, we only take the most recent HH survey into consideration for the computation of the *AHI*. A next step would be to apply our

methodology in a time-series to estimate changes in housing needs over time to help better project future demand for housing.

Further, since geo-referenced data is only available for a few HCES surveys, we are constrained in performing more nuanced disaggregated analyzes on location or including satellite imagery to estimate changes in urbanization more precisely. In addition, housing deficit calculations like the one suggested by the application of *AHI,* are limited to homogeneous criteria across countries or rural and urban areas. From a policy perspective, a more informative picture would be the analysis of each city separately with the best available data. However, while it is very informative at the city level, the main purpose of this paper is to provide a framework for comparable assessments of housing deficit numbers. Despite these caveats, the *AHI* provides the first comparative, micro-founded assessment of housing adequacy across 64 emerging economies, and one that can quantify disparities within countries. Large variations across and within countries vividly show that there is no one-size-fits-all solution for adequate housing challenges.

Ultimately, this paper provides one side of the puzzle that encompasses a wide-ranging housing value chain. For example, for the analysis of the supply of housing targeted at different segments, housing prices, housing finance and housing policy are all elements that are needed to put the estimates from this paper in context and implementable use. Bringing these various elements together in the analysis of the country's housing market is fundamental to more fully understanding housing needs and challenges faced by households in emerging economies.

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Annex 1: Coding of WASH Dimensions

Joint Monitoring Program classification of improved drinking-water and sanitation facilities based on the Methodology Update (March 2018)

WATER	Improved	Unimproved
Tap Water	- Piped water into dwelling - Piped water to yard/plot - Public tap, standpipe - Covered cistern/tank - Uncovered cistern/tank - Bottled water - Sachet water - Cart with small tank/ drum - Tanker truck provided	
Ground Water	- Tube well, borehole - Protected well - Protected spring	- Unprotected spring - Unprotected well
Rainwater	- Covered cistern/tank - Uncovered cistern/tank	
Packaged Water	- Bottled water - Sachet water	
Delivered Water	- Cart with small tank/ drum - Tanker truck provided	
Surface Water		- River - Lake - Dam - Pond - Stream - Irrigation Channel

SANITATION	Improved	Unimproved
Flush toilets	- to piped sewer system - to septic tank - to pit - to unknown place/not sure/DK	- to open drain - to elsewhere
Pour flush latrines	- to piped sewer system - to septic tank - to pit - to unknown place/not sure/DK	- to elsewhere
Dry latrines	- Ventilated Improved pit latrine - Composting toilets - Pit latrine with slab	- Pit latrine without slab/ open pit - Hanging toilet/hanging latrine - Bucket latrine
No facility		- Bush - Field

Annex 2: Country and Survey List

Country	Region	Survey name	Latest Survey year	Country	Region	Survey name	Latest Survey year
Albania	ECA	HBS	2018	Lao PDR	EAP	LECS	2012
Angola	SSA	IDREA	2018	Madagascar	SSA	ENSOMD	2012
Argentina	LAC	EPHC-S2	2018	Malawi	SSA	IHS-IV	2016
Bangladesh	SAR	HIES	2016	Mali	SSA	DHS	2018
Belarus	ECA	HHS	2018	Mexico	LAC	ENIGHS	2018
Benin	SSA	EMICOV	2015	Morocco	MENA	ENCDM	2013
Botswana	SSA	BMTHS	2015	Mozambique	SSA	IOF	2014
Brazil	LAC	PNADC-E1	2018	Mynamnar	EAP	MPLCS	2015
Burkina Faso	SSA	EMC	2014	Nepal	SAR	LSS-III	2010
Burundi	SSA	ECVMB	2013	Nicaragua	LAC	EMNV	2014
Cameroon	SSA	ECAM-IV	2014	Niger	SSA	ECVMA	2014
Chad	SSA	ECOSIT-III	2011	Nigeria	SSA	GHSP	2015
Colombia	LAC	GEIH	2018	Pakistan	SAR	PSLM	2015
Congo, Dem. Rep.	SSA	E123	2012	Peru	LAC	SEDLAC-03	2018
Congo, Rep.	SSA	ECOM	2011	Philippines	EAP	FIES	2015
Costa Rica	LAC	ENAHO	2018	Romania	ECA	HBS	2016
Cote D'Ivoire	SSA	ENV	2015	Russian Federation	ECA	HBS	2015
Djibouti	SSA	EDAM	2017	Rwanda	SSA	EICV	2016
Dominican Republic	LAC	ECNFT-Q03	2018	Senegal	SSA	ESPS	2011
Egypt, Arab Rep.	MENA	HIECS	2017	Sierra Leone	SSA	SLIHS	2011
Ethiopia	SSA	HICES	2015	South Africa	SSA	LCS	2014
Gabon	SSA	EGEP	2017	Sri Lanka	SAR	HIES	2016
Gambia	SSA	IHS	2015	Sudan	SSA	NBHS	2014
Ghana	SSA	GLSS-VII	2016	Tanzania	SSA	HBS	2018
Guinea	SSA	ELEP	2012	Togo	SSA	QUIBB	2015
Guinea-Bissau	SSA	ILAP-II	2010	Tunisia	SSA	NSHBCSL	2015
Haiti	LAC	ECVMAS	2012	Turkey	MENA	HICES	2018
India	SAR	DHS	2015	Uganda	SSA	UNHS	2016
Indonesia	EAP	SUSENAS	2016	Ukraine	ECA	HLCS	2018
Iraq	MENA	IHSES	2012	Uzbekistan	ECA	L2CU	2018
Kazakhstan	ECA	HBS	2018	Vietnam	EAP	VHLSS	2014
Kenya	SSA	IHBS	2015	Zambia	SSA	LCMS-VII	2015

Annex 3: Summary Statistics of Adequacy Dimensions

3.1 Adequacy Dimensions by Country

Country	Access to Water	Access to Sanitation	Good Structural Quality	Adequate Living Space	Tenure Security	Access to Clean Cooking	Access to Electricity
Albania	0.91	0.96	0.92	0.94	0.83	0.76	1.00
Angola	0.67	0.69	0.51	0.90	0.70	0.48	0.45
Argentina	1.00	0.99	0.99	1.00	0.82	1.00	1.00
Bangladesh	0.97	0.61	0.31	0.84	0.70	0.15	0.76
Belarus	0.95	0.94	0.67	0.99	0.91	0.95	0.98
Benin	0.74	0.32	0.46	0.86	0.70	0.04	0.31
Botswana	0.96	0.65	0.01	0.96	0.70	0.67	0.64
Brazil	0.98	0.97	0.96	1.00	0.76	0.99	1.00
Burkina Faso	0.81	0.38	0.44	0.70	0.51	0.09	0.23
Burundi	0.81	0.62	0.06	0.97	0.93	0.00	0.07
Cameroon	0.70	0.64	0.45	0.95	0.67	0.29	0.62
Chad	0.53	0.07	0.05	0.67	0.82	0.02	0.03
Colombia	0.96	0.92	0.62	0.98	0.74	0.90	0.98
Congo, Dem. Rep.	0.50	0.28	0.02	0.90	0.76	0.06	0.16
Congo, Rep.	0.79	0.52	0.59	0.92	0.67	0.15	0.40
Costa Rica	0.99	0.98	0.98	1.00	0.86	0.95	1.00
Côte d'Ivoire	0.78	0.47	0.63	0.89	0.72	0.23	0.66
Djibouti	0.91	0.73	0.06	0.69	0.64	0.20	0.63
Dominican Republic	0.91	0.94	0.93	0.99	0.73	0.92	0.99
Egypt, Arab Rep.	0.98	0.98	0.87	0.99	0.85	1.00	0.99
Ethiopia	0.65	0.07	0.04	0.64	0.77	0.05	0.72
Gabon	0.89	0.72	0.51	0.96	0.58	0.83	0.91
Gambia, The	0.92	0.65	0.62	0.85	0.72	0.01	0.58
Ghana	0.91	0.82	0.65	0.80	0.65	0.25	0.83
Guinea	0.68	0.36	0.36	0.85	0.69	0.00	0.24
Guinea-Bissau	0.63	0.35	0.04	0.78	0.76	0.01	0.03
Haiti	0.66	0.29	0.62	0.77	0.73	0.03	0.33
India	0.95	0.58	0.52	0.65	0.79	0.45	0.88
Indonesia	0.89	0.83	0.71	0.89	0.72	0.73	0.98
Iraq	0.91	0.99	0.79	0.48	0.72	0.98	1.00
Kazakhstan	1.00	0.99		0.97	0.92	0.99	1.00
Kenya	0.76	0.90	0.08	0.80	0.70	0.15	0.43
Lao PDR	0.75	0.70	0.43	0.81	0.82	0.06	0.80
Madagascar	0.43	0.25	0.18	0.56	0.74	0.01	0.24
Malawi	0.87	0.71	0.26	0.87	0.81	0.02	0.11

Country	Access to Water	Access to Sanitation	Good Structural Quality	Adequate Living Space	Tenure Security	Access to Clean Cooking	Access to Electricity
Mali	0.69	0.55	0.28	0.81	0.28	0.01	0.49
Mexico	0.96	0.94	0.74	1.00	0.82	0.84	1.00
Morocco	0.92	0.87	0.89	0.93	0.79	0.99	0.98
Mozambique	0.59	0.29	0.24	0.67	0.73	0.03	0.29
Myanmar	0.71	0.80	0.11	0.76	0.83	0.16	0.60
Nepal	0.91	0.56	0.35	0.87	0.89	0.18	0.70
Nicaragua	0.89	0.58	0.50	0.84	0.79	0.48	0.82
Niger	0.53	0.16	0.07	0.23	0.73	0.02	0.15
Nigeria	0.76	0.60	0.18	0.87	0.78	0.05	0.59
Pakistan	0.93	0.73	0.50	0.59	0.80	0.46	0.79
Peru	0.95	0.91	0.87	0.94	0.79	0.75	0.96
Philippines	0.90	0.94	0.63	0.61	0.57	0.47	0.91
Romania	0.99	0.74	0.95	0.88	0.93	0.99	0.99
Russian Federation	0.94	0.89		0.96	0.92		0.95
Rwanda	0.77	0.86	0.03	0.88	0.95	0.01	0.34
Senegal	0.71	0.69	0.66	0.79	0.77	0.28	0.57
Sierra Leone	0.69	0.31	0.36	0.82	0.61	0.00	0.14
South Africa	0.95	0.95	0.57	0.96	0.71	0.85	0.93
Sri Lanka	0.89	0.99	0.88	0.88	0.72	0.29	0.97
Sudan	0.80	0.59	0.13	0.68	0.82	0.41	0.55
Tanzania	0.72	0.39	0.48	0.81	0.80	0.07	0.29
Togo	0.64	0.42	0.51	0.83	0.67	0.08	0.49
Tunisia	0.98	0.94	0.98	0.97	0.81	1.00	1.00
Turkey	1.00	0.95	0.88	0.99	0.66	0.98	1.00
Uganda	0.81	0.44	0.38	0.76	0.74	0.01	0.39
Ukraine	0.81	0.81		0.99	0.92	0.95	0.97
Uzbekistan	0.96	0.86			0.95	0.96	0.97
Vietnam	0.93	0.76	0.82		0.88		0.99
Zambia	0.68	0.40	0.45	0.87	0.69	0.16	0.36

Note: Adequacy Dimension by Country based on latest available Household and Consumption Survey as outlined in Annex 2. Empty cells denote missing data for that dimensions (imputation impossible due to absence of data in both HCES and DHS).

3.2 Correlation Matrix of Adequacy Dimensions

Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) Access to Water	1.000						
(2) Access to Sanitation	0.276***	1.000					
(3) Good Structural Quality	0.236***	0.427***	1.000				
(4) Adequate Living Space	0.061***	0.227***	0.183***	1.000			
(5) Tenure Security	0.007***	0.027***	0.020***	0.064***	1.000		
(6) Access to Clean Cooking	0.258***	0.488***	0.492***	0.230***	0.069***	1.000	
(7) Access to Electricity	0.312***	0.406***	0.386***	0.131***	0.057***	0.461***	1.000

**** p<0.01, ** p<0.05, * p<0.1*

Annex 4: Comparing Alternate Weights: Principal Component Analysis and Strict AHI

Testing the robustness of the weighting scheme applied to *AHI*, we compare alternate weighting options and present the results in the table below. We compare the *strict Adequate Housing Index (sAHI*) which aligns with propositions of many multilateral institutions such as the UN on how to estimate the housing deficit (cf. Equation 3 in Section 3.3) and also present an *AHI* which derives weights through Principal Component Analysis ($_{PCA}AHI$). Principal Component Analysis (PCA) is a technique often used to extract weights in composite indices.[21] PCA is widely applied in indicator development across different topic areas including wealth, quality of life, or sustainability (for an overview: Greco et al. 2018). With PCA, the seven adequacy dimensions are aggregated through a linear combination without an *a priori* rationale for assigning weights to the respective adequacy dimensions. The magnitude of the coefficient on any one of the adequacy dimensions measures the importance of that dimensions to the principal component irrespective of the other adequacy dimensions.

Following Filmer and Pritchett's (2001) seminal approach, who condense multi-dimensional information on ownership of various household assets through PCA to estimate wealth effects, we interpret the first principal component as a proxy for overall housing adequacy as it captures the largest variation of the data (see also Filmer and Scott 2008; McKenzie 2005; Vyas and Kumaranayake 2006). The adequacy dimension which varies most across households is given a larger weight. An adequacy dimension which all (or no) HHs have is given zero weight in the first principal component, as it explains none of the variation. In some countries, deficiencies on e.g., adequate cooking might affect only few HHs. In contrast, tenure insecurity might affect almost all HHs within a given country due to some regulatory issues in providing legal titles or securing property rights. In both cases, PCA assigns weights that are close to zero given the limited variance across HHs.

[21] Given that PCA was originally developed for multivariate data, it is often argued that it is best used with continuous data. As a small but growing body of literature critiques the use of discrete data in multivariate methods like PCA (e.g., Kolenikov & Angeles 2009), we also checked the robustness of the $_{PCA}AHI$ by running an alternate PCA specification with assumption better suited for discrete data (*results omitted*). We use polychoric correlations which are argued to be more suitable for dummy variables. We run a PCA on the polychoric correlation matrix which differs slightly from the standard Pearson correlation matrix. The literature on the use of polychoric PCA is sparse but growing in recognition (e.g., Di Bartolo 2000; Kolenikov & Angeles 2009). With respect to the robustness of the $_{PCA}AHI$, the differences between the polychoric method and the standard PCA method were minimal with virtually no difference at national level and very minor differences (at second decimal point at lower income deciles) if disaggregated across incomes. Analogous to Kolenikov and Angeles (2009), polychoric PCA methods demonstrated small divergences at the lower end of the income spectrum with increasing agreement of classification on the upper end.

By design, the PCA-based weighting uses country-specific relative weights on each adequacy dimension. Conceptually such an aggregation method considers country context on the relative importance of each dimension within a country and has more practicability when it comes to providing country-specific recommendations on how to address the housing adequacy deficit. To test the influence of country-specific weights on the ranking of AHI across countries, we re-run alternate PCA estimations *across* all countries, estimating weights per adequacy dimensions *over all* countries. This aggregation into the alternate $_{PCA}AHI$ ignores country context and applies uniform weighting of each dimension across countries. The results *[omitted here]* of this aggregation method change $_{PCA}AHI$ marginally (never exceeding a 10-percentage point difference).

Comparing Different Weighting Schemes across Countries

Country	*s*AHI	$_{PCA}$AHI	AHI
Albania	0.84	0.81	0.90
Angola	0.19	0.54	0.63
Argentina	0.98	0.97	0.97
Bangladesh	0.35	0.46	0.62
Belarus	0.64	0.84	0.91
Benin	0.02	0.38	0.49
Botswana	0.00	0.72	0.66
Brazil	0.92	0.97	0.95
Burkina Faso	0.07	0.38	0.45
Burundi	0.00	0.33	0.50
Cameroon	0.19	0.53	0.62
Chad	0.00	0.15	0.31
Colombia	0.60	0.88	0.87
Congo, Dem. Rep.	0.00	0.22	0.38
Congo, Rep.	0.11	0.50	0.58
Costa Rica	0.92	0.97	0.97
Côte d'Ivoire	0.14	0.57	0.63
Djibouti	0.00	0.77	0.54
Dominican Republic	0.79	0.93	0.92
Egypt, Arab Rep.	0.83	0.94	0.95
Ethiopia	0.02	0.38	0.42
Gabon	0.36	0.76	0.77
Gambia, The	0.01	0.55	0.62
Ghana	0.19	0.67	0.70
Guinea	0.00	0.38	0.46
Guinea-Bissau	0.00	0.24	0.37
Haiti	0.01	0.40	0.49

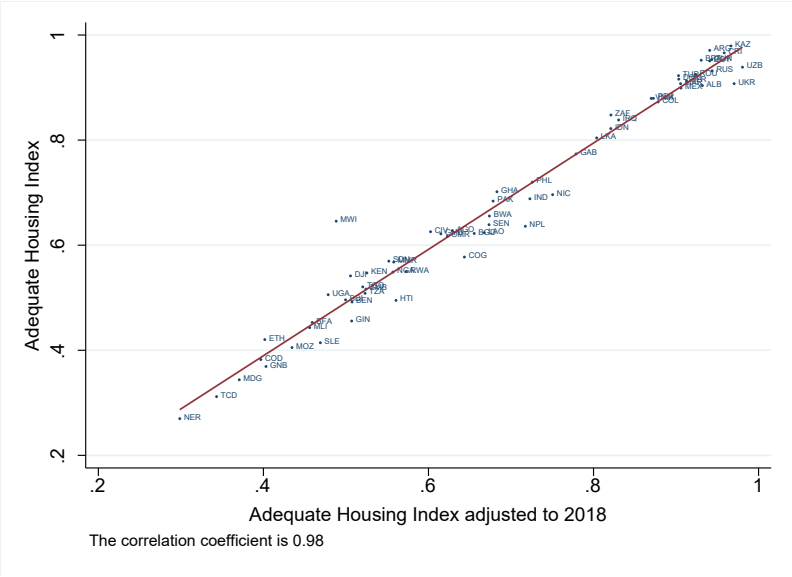
Country	$_{S}$AHI	$_{PCA}$AHI	AHI
India	0.23	0.62	0.69
Indonesia	0.53	0.81	0.82
Iraq	0.37	0.87	0.84
Kazakhstan	0.96	0.76	0.98
Kenya	0.05	0.50	0.55
Lao PDR	0.04	0.61	0.62
Madagascar	0.01	0.28	0.34
Malawi	0.02	0.36	0.52
Mali	0.00	0.54	0.44
Mexico	0.67	0.89	0.90
Morocco	0.72	0.89	0.91
Mozambique	0.02	0.37	0.41
Myanmar	0.05	0.48	0.57
Nepal	0.14	0.49	0.64
Nicaragua	0.30	0.67	0.70
Niger	0.01	0.20	0.27
Nigeria	0.01	0.51	0.55
Pakistan	0.37	0.60	0.68
Peru	0.60	0.90	0.88
Philippines	0.53	0.72	0.72
Romania	0.64	0.86	0.92
Russian Federation	0.77	0.93	0.93
Rwanda	0.01	0.40	0.55
Senegal	0.32	0.61	0.64
Sierra Leone	0.00	0.36	0.41
South Africa	0.50	0.82	0.85
Sri Lanka	0.25	0.80	0.80
Sudan	0.07	0.52	0.57
Tanzania	0.05	0.43	0.51
Togo	0.06	0.46	0.52
Tunisia	0.89	0.96	0.95
Turkey	0.82	0.94	0.92
Uganda	0.01	0.44	0.51
Ukraine	0.75	0.82	0.91
Uzbekistan	0.77	0.89	0.94
Vietnam	0.67	0.86	0.88
Zambia	0.14	0.43	0.52

Annex 5: Comparison of HH level data with Macro Data

As some countries that we analyze have dated surveys (Iraq (2012), Madagascar (2012), or Senegal (2011)), we estimate how the AHI changes if the seven adequacy dimensions are scaled to 2018. Hence, we project how four of the seven adequacy dimensions, for which we have macro data available (access to water, access to sanitation, tenure security, access to electricity, and secure cooking fuel) changed between the year of the survey and 2018. Since we use recent PRINDEX data to estimate tenure security, we abstain from making additional adjustments to that adequacy dimension. Making use of the adjusted data, we compute a new, adjusted *AHI* where data from every household survey is now scaled to 2018 as the reference year.

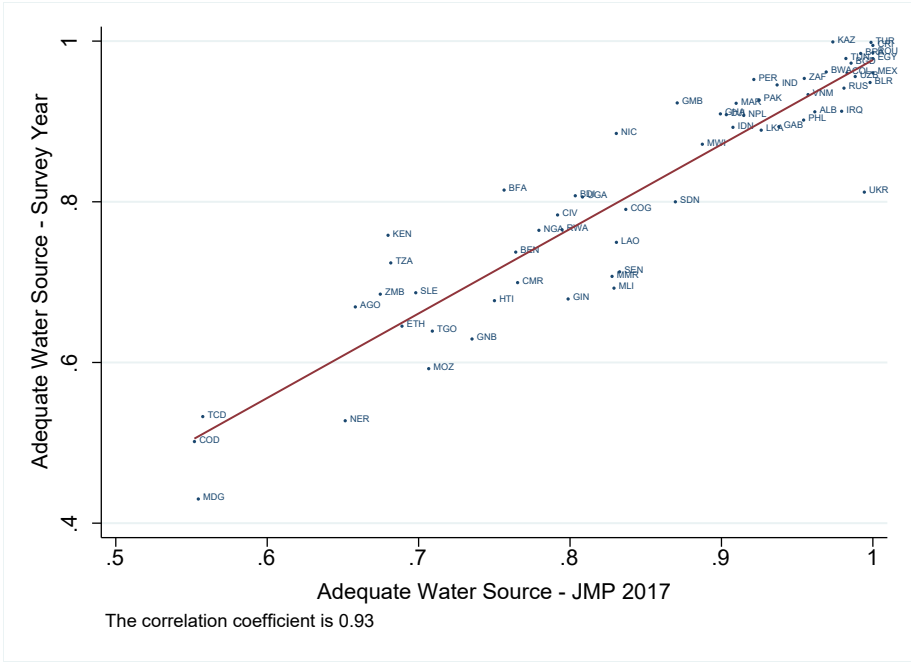
The following figure compares the adjusted *AHI* (data scaled to 2018) to the original *AHI* (original data of the respective survey year) which we use in this paper to report findings (Figure 4).

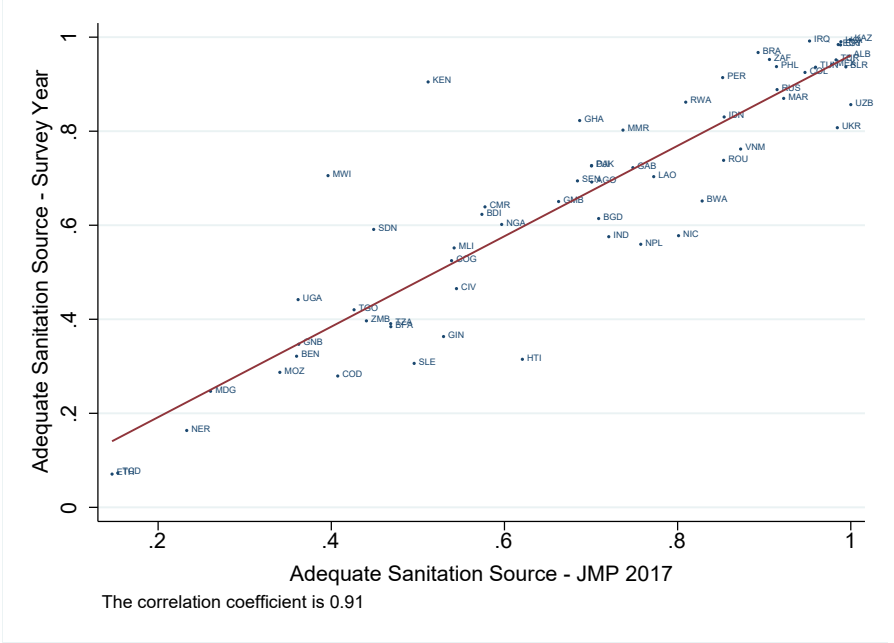
Figure 4 Overall Adequate Housing Index: Comparison of Adjusted vs. Unadjusted Data



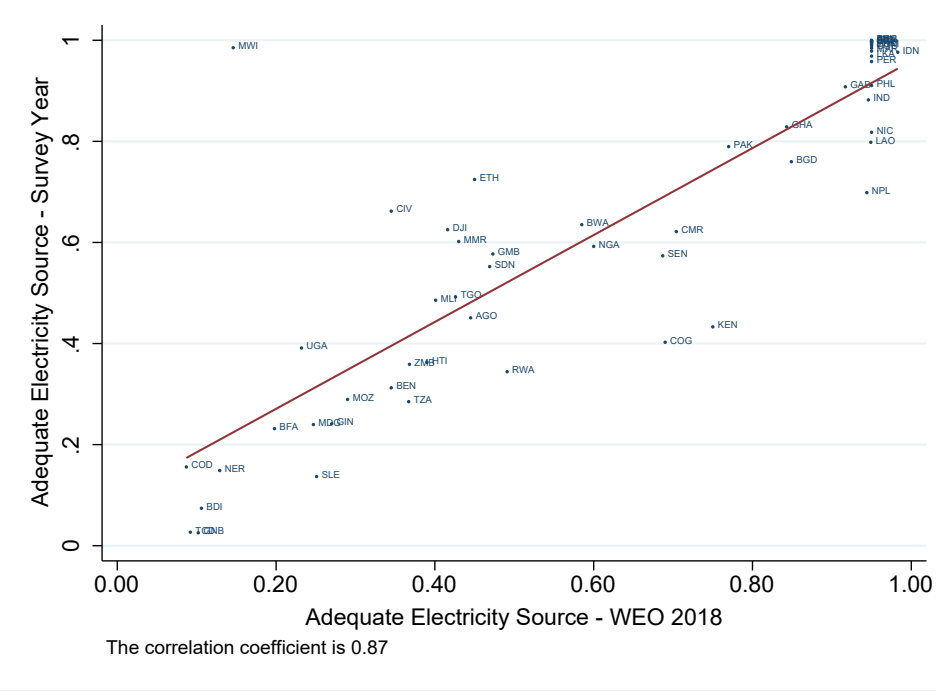
We also compare the individual original adequacy dimensions (country averages) generated from the respective survey year with macro data that match closest with our definition (Figure 5). The differences between the two are minor except for a few countries, where there are significant changes between the year of the survey and the most recently available year of the macro data (2017 for WASH variables and 2018 for electricity and cooking).

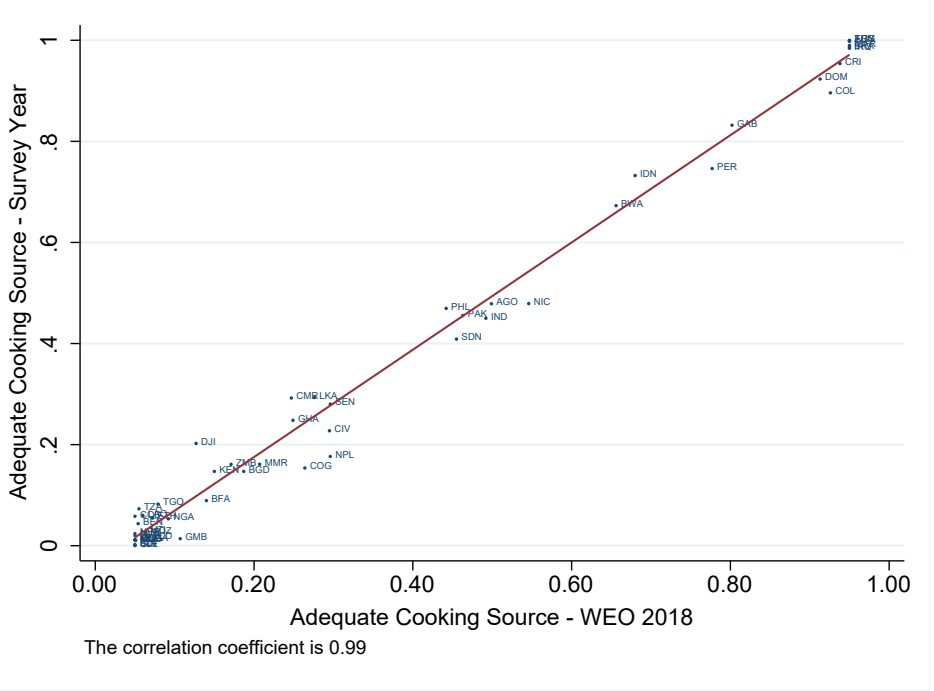
Figure 5 Individual Adequacy Dimensions: Comparing Averages of Original Adequacy Dimensions and Macro Data





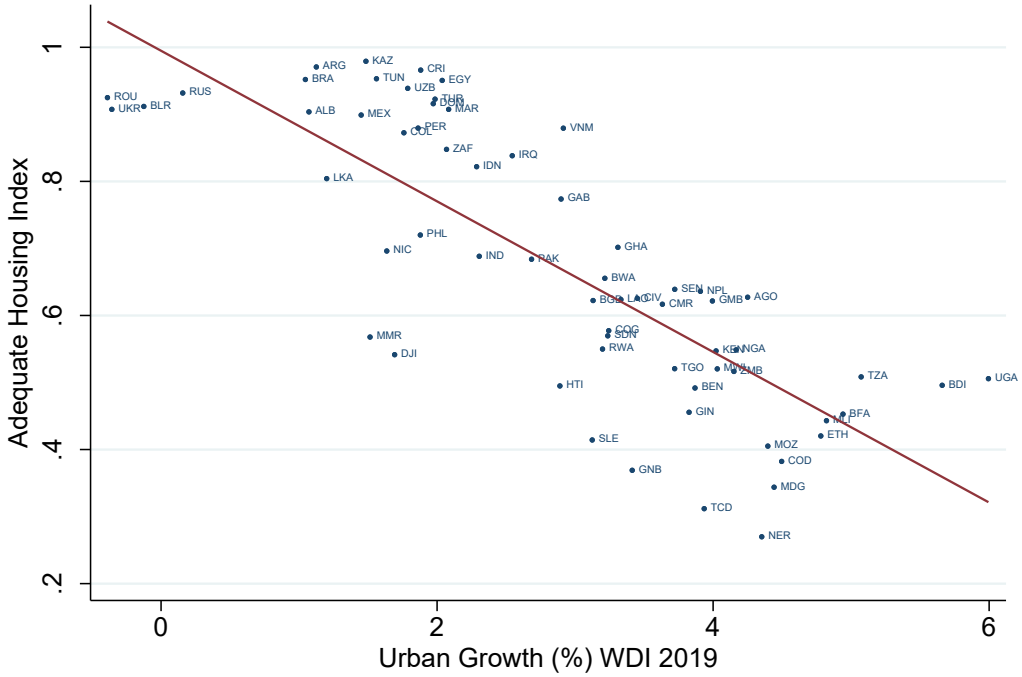
Note: *Access to improved water and sanitation from respective survey year* compared to *Access to improved water and sanitation from Joint Monitoring Programme 2017* (Source: Authors' calculation of latest HCES survey and Joint Monitoring Programme 2017).





Note: *Access to electricity and cooking from respective survey year* compared to *Access to electricity and cooking from World Energy Outlook 2018* (Source: Authors' calculation of HCES survey and World Energy Outlook 2018).

Annex 6: Correlation of Adequate Housing Index and Urban Growth



Source: World Bank

Note: Housing Adequacy Index and urban growth (Source: Authors' calculation of HCES survey and WDI 2019). The correlation coefficient is .80

Annex 7: Rural and Urban Housing Deficit

	RURAL		*Stock Deficit - current year*		*Flow Deficit - 2030*	URBAN		*Stock Deficit - current year*		*Flow Deficit - 2030*
Country*	AHI - Rural Average	Rural Households (In million)	Inadequate Rural Housing Units (In million)	Inadequate Rural Housing Units per capita	Inadequate Rural Housing Units projected to 2030 (In million)	AHI - Urban Average	Urban Households (In million)	Inadequate Urban Housing Units (In million)	Inadequate Urban Housing Units per capita	Inadequate Urban Housing Units projected to 2030 (In million)
Angola	0.39	2.20	1.35	0.13	1.54	0.79	4.10	0.86	0.04	1.33
Argentina						0.97	13.62	0.40	0.01	0.44
Bangladesh	0.59	24.85	10.15	0.10	9.68	0.70	15.52	4.64	0.08	6.22
Belarus	0.82	0.87	0.16	0.08	0.12	0.95	3.00	0.16	0.02	0.16
Benin	0.40	1.38	0.83	0.13	0.97	0.59	1.41	0.58	0.10	0.86
Botswana	0.53	0.34	0.16	0.24	0.15	0.73	0.78	0.21	0.13	0.28
Brazil	0.91	8.94	0.81	0.03	0.70	0.96	63.42	2.62	0.01	2.86
Burkina Faso	0.36	1.79	1.14	0.08	1.39	0.69	1.03	0.32	0.05	0.53
Burundi	0.49	2.09	1.07	0.11	1.40	0.59	0.31	0.13	0.08	0.23
Cameroon	0.48	2.31	1.21	0.11	1.35	0.79	3.63	0.76	0.05	1.10
Chad	0.29	2.15	1.54	0.13	1.99	0.42	0.70	0.41	0.11	0.64
Colombia	0.74	2.69	0.70	0.07	0.62	0.91	12.45	1.13	0.03	1.25
Congo, Dem. Rep.	0.32	9.98	6.75	0.14	8.20	0.49	7.25	3.71	0.09	5.89
Congo, Rep.	0.39	0.43	0.26	0.15	0.29	0.68	0.83	0.27	0.07	0.38
Costa Rica	0.94	0.31	0.02	0.02	0.01	0.97	1.26	0.03	0.01	0.04
Cote d'Ivoire	0.49	3.62	1.86	0.15	2.16	0.73	3.65	0.99	0.07	1.43
Djibouti	0.31	0.05	0.04	0.17	0.04	0.60	0.14	0.06	0.08	0.07
Dominican Republic	0.87	0.66	0.09	0.05	0.07	0.93	2.79	0.20	0.02	0.23
Egypt, Arab Rep.	0.94	13.02	0.76	0.01	0.88	0.96	11.07	0.43	0.01	0.54
Ethiopia	0.38	17.97	11.21	0.13	13.46	0.56	6.50	2.86	0.12	4.68
Gabon	0.62	0.06	0.02	0.11	0.02	0.81	4.98	0.09	0.05	0.12
Gambia, The	0.51	0.11	0.05	0.06	0.06	0.69	0.25	0.08	0.05	0.11
Ghana	0.60	3.08	1.24	0.09	1.30	0.78	4.99	1.08	0.06	1.50
Guinea	0.36	1.28	0.82	0.10	1.01	0.67	0.70	0.23	0.05	0.35
Guinea-Bissau	0.36	0.12	0.08	0.07	0.09	0.39	0.11	0.07	0.08	0.10
Haiti	0.41	1.00	0.59	0.12	0.53	0.58	1.36	0.57	0.09	0.74
India	0.61	185.57	73.01	0.08	73.39	0.84	106.03	16.87	0.04	21.62
Indonesia	0.76	32.18	7.80	0.07	7.28	0.88	41.20	4.82	0.03	5.98
Iraq	0.77	1.48	0.34	0.03	0.39	0.86	4.39	0.60	0.02	0.80
Kazakhstan	0.99	2.00	0.03	0.00	0.03	0.97	3.42	0.09	0.01	0.10
Kenya	0.47	8.42	4.48	0.12	5.20	0.65	4.42	1.55	0.11	2.38
Lao PDR	0.57	0.87	0.38	0.08	0.38	0.75	0.52	0.13	0.05	0.18
Madagascar	0.31	3.65	2.53	0.15	2.94	0.51	2.51	1.24	0.12	1.96
Malawi	0.62	3.59	1.36	0.09	1.73	0.75	0.75	0.19	0.06	0.31
Mali	0.38	1.94	1.21	0.11	1.42	0.67	1.38	0.45	0.05	0.73
Mexico	0.78	6.52	1.42	0.06	1.32	0.93	29.05	1.93	0.02	2.22
Morocco	0.85	2.53	0.38	0.03	0.36	0.94	5.15	0.32	0.01	0.39
Mozambique	0.30	3.10	2.16	0.11	2.64	0.62	1.75	0.66	0.06	1.05
Myanmar	0.51	8.29	4.09	0.11	4.16	0.73	3.65	0.99	0.06	1.21
Nepal	0.59	4.60	1.87	0.08	2.04	0.79	1.31	0.27	0.05	0.39
Nicaragua	0.51	0.59	0.29	0.11	0.30	0.83	0.91	0.15	0.04	0.18
Niger	0.21	2.95	2.33	0.12	3.39	0.57	0.61	0.26	0.07	0.44
Nigeria	0.48	16.21	8.45	0.09	9.24	0.65	20.42	7.11	0.07	10.76
Pakistan	0.62	21.22	7.97	0.06	9.10	0.79	13.33	2.84	0.04	3.80
Peru	0.74	2.09	0.54	0.08	0.53	0.92	7.02	0.56	0.02	0.64
Philippines	0.67	12.30	4.02	0.07	4.27	0.78	11.12	2.45	0.05	3.02
Romania	0.89	3.19	0.37	0.04	0.33	0.96	4.15	0.16	0.02	0.16
Russia	0.94	13.09	0.82	0.02	0.73	0.93	40.99	2.87	0.03	2.91
Rwanda	0.52	2.37	1.13	0.11	1.41	0.66	0.55	0.19	0.09	0.27
Senegal	0.51	0.84	0.41	0.05	0.48	0.77	0.98	0.22	0.03	0.33
Sierra Leone	0.35	0.79	0.51	0.11	0.57	0.51	0.62	0.30	0.09	0.42
South Africa	0.79	4.26	0.91	0.05	0.86	0.88	11.02	1.38	0.04	1.67
Sri Lanka	0.79	4.72	0.97	0.05	0.97	0.86	1.02	0.15	0.04	0.17
Sudan	0.50	4.09	2.04	0.07	2.44	0.70	2.19	0.66	0.04	0.97
Tanzania	0.40	7.76	4.69	0.12	5.62	0.71	4.79	1.37	0.07	2.30
Togo	0.36	0.87	0.56	0.12	0.64	0.70	0.82	0.25	0.07	0.37
Tunisia	0.92	0.83	0.06	0.02	0.06	0.97	2.08	0.07	0.01	0.08
Uganda	0.44	7.17	4.01	0.12	4.90	0.67	2.81	0.92	0.09	1.59
Ukraine	0.82	5.07	0.93	0.07	0.80	0.95	12.15	0.59	0.02	0.57
Uzbekistan	0.93	3.15	0.23	0.01	0.25	0.97	3.91	0.12	0.01	0.14
Vietnam	0.85	16.12	2.48	0.04	2.34	0.94	9.28	0.52	0.01	0.69
Zambia	0.37	1.91	1.20	0.12	1.45	0.71	1.57	0.45	0.06	0.70

Note: *Latest HCES surveys of Albania and Turkey have missing data for location

Annex 8: Housing Stock Deficit: Building New Housing Units

Country	**Total Stock Deficit**	New housing units required	Percentage of new housing units required
Albania	75,063	4,129	0.06
Angola	2,214,224	242,665	0.11
Argentina	399,001	1,205	0.00
Bangladesh	14,788,946	2,346,765	0.16
Belarus	314,760	2,295	0.01
Benin	1,405,766	197,586	0.14
Botswana	376,609	14,695	0.04
Brazil	3,432,493	3,980	0.00
Burkina Faso	1,460,566	445,642	0.31
Burundi	1,201,346	30,749	0.03
Cameroon	1,967,370	106,382	0.05
Chad	1,942,103	646,468	0.33
Colombia	1,834,378	41,394	0.02
Congo, Dem. Rep.	10,461,244	1,060,278	0.10
Congo, Rep.	529,447	41,476	0.08
Costa Rica	50,103	188	0.00
Côte d'Ivoire	2,847,556	302,020	0.11
Djibouti	92,927	29,821	0.32
Dominican Republic	287,832	2,742	0.01
Egypt, Arab Rep.	1,188,618	14,406	0.01
Ethiopia	14,071,058	5,151,390	0.37
Gabon	117,739	5,186	0.04
Gambia, The	128,874	19,101	0.15
Ghana	2,316,975	480,941	0.21
Guinea	1,050,757	156,289	0.15
Guinea-Bissau	147,108	33,258	0.23
Haiti	1,156,936	275,614	0.24
India	89,876,792	32,177,878	0.36
Indonesia	12,616,650	1,344,546	0.11
Iraq	936,917	498,268	0.53
Kazakhstan	112,191	3,555	0.03
Kenya	6,028,502	1,239,765	0.21
Lao PDR	506,104	101,076	0.20
Madagascar	3,771,918	1,570,892	0.42
Malawi	2,093,650	275,439	0.13

Country	**Total Stock Deficit**	New housing units required	Percentage of new housing units required
Mali	1,658,646	316,433	0.19
Mexico	3,352,947	19,465	0.01
Morocco	692,206	50,944	0.07
Mozambique	2,819,270	984,095	0.35
Myanmar	5,073,738	1,254,231	0.25
Nepal	2,135,150	264,796	0.12
Nicaragua	444,945	74,436	0.17
Niger	2,592,186	2,047,194	0.79
Nigeria	15,556,022	2,131,957	0.14
Pakistan	10,809,068	4,488,124	0.42
Peru	1,095,247	66,447	0.06
Philippines	6,467,408	2,512,956	0.39
Romania	529,185	65,525	0.12
Russian Federation	3,689,915	152,093	0.04
Rwanda	1,315,094	159,456	0.12
Senegal	633,799	132,447	0.21
Sierra Leone	810,147	141,502	0.17
South Africa	2,285,071	90,412	0.04
Sri Lanka	1,118,817	126,932	0.11
Sudan	2,703,073	880,442	0.33
Tanzania	6,059,465	1,249,426	0.21
Togo	809,139	134,323	0.17
Tunisia	135,655	4,569	0.03
Turkey	1,909,879	10,613	0.01
Uganda	4,933,434	1,206,718	0.24
Ukraine	1,520,995	16,306	0.01
Uzbekistan	346,318	-	-
Vietnam	3,001,425	-	-
Zambia	1,654,346	234,012	0.14

Note: Fraction of Housing Deficit that requires building of new housing. Based on calculations outlined in Section 5.1.