Too few nutrients and too many calories: Climate change and the double burden of malnutrition in Asia

Raya Muttarak[1,2]

[1] School of International Development, University of East Anglia, United Kingdom
[2] Wittgenstein Centre for Demography and Global Human Capital (IIASA, VID/ÖAW and WU), International Institute for Applied Systems Analysis, Austria

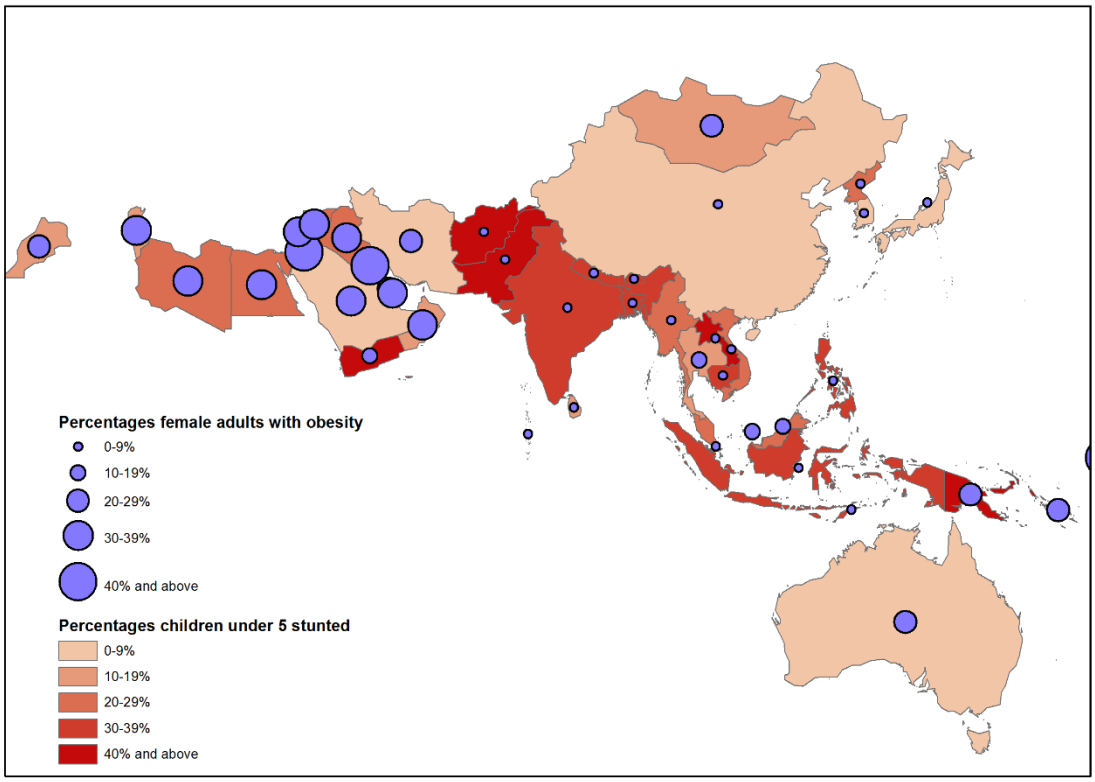
Given the estimate of 151 million children (22%) under 5 year of age (of which 84 million residing in Asia) suffering from undernutrition – measured as growth stunting in 2017 (UNICEF, WHO, & World Bank, 2018) – the United Nations has set ending hunger as one key priority of the Sustainable Development Goals (SDGs). Meanwhile, the problem of overweight and obesity has also become alarming with 38 million children under 5 (17.5 million in Asia) classified as overweight in 2017 (UNICEF et al., 2018). Both under- and over-nutrition can have long lasting impacts on health and wellbeing. Under-nutrition in children increases mortality risks and impedes physical and mental capability, consequently leading to poor schooling outcomes and reduced earnings in adulthood (Bhutta, 2013; Hoddinott et al., 2013; Martins et al., 2011). Likewise, over-nutrition – a form of malnutrition from excessive intake of nutrients manifested by obesity – is associated with many risk factors for chronic disorders including type 2 diabetes, hypertension and coronary heart disease as well as increased risk of all-cause and cause-specific mortality (Abdullah et al., 2011; Park, Falconer, Viner, & Kinra, 2012). Both under- and over-nutrition may undermine progress in sustainable development.

What is more challenging to sustainable development is the dual burden of malnutrition – defined as a concurrence of under- and overnutrition. This can coexist within the same individual, household, community, region and country. One of the most common forms of this malnutrition paradox is maternal overweight with child underweight or stunting. Particularly for low- and middle-income countries undergoing nutritional transition, rapid urbanisation and integration to global markets lead to a shift towards more energy-dense yet nutrient-poor diets and sedentary lifestyles resulting in over-nutrition (Popkin, 1994). At the same time, whilst improved socioeconomic conditions help bring down the number of undernourished children, disparities in economic development result in persistence in undernutrition (Bredenkamp, Buisman, & Van de Poel, 2014). Indeed, income inequality at the regional or country level explains the coexistence of under- and over-nutrition as shown in the study on India (Mazumdar, 2010; Subramanian & Kawachi, 2007) and Indonesia (Hanandita & Tampubolon, 2015).

As shown in Figure 1, for many Asian countries, especially those in South and Southeast Asia, childhood undernutrition remains a serious public health problem. The prevalence of children aged under 5 being stunted in these regions ranges from 10.5% in Thailand (2016) to 20.7% in Malaysia (2016), 32.4% in Cambodia (2014), 37.9% in India (2015) and 45% in Pakistan (2012). Meanwhile, the share of female adults aged 18 years and over with obesity is particularly high in Central and Western Asia: 29.3% in Iran (2011), 34.3% in Iraq (2011), 41% in Jordan (2012) and 45% in Kuwait (2015). At the country level, some higher middle income countries such as Thailand, Malaysia, Lebanon, Oman and Qatar clearly manifest the dual burden of malnutrition with the prevalence of both childhood stunting and female adult obesity being over 10% for the former and mainly over 20% for the latter. The dual burden of malnutrition in small-island states in the Pacific is notably alarming. Papua New Guinea (2010) and Solomon Islands (2015), for instance, suffer from 49.5% and 31.6% of undernutrition in children, respectively but at the

same time experience 22.2% and 26.5% of obesity in female adults, respectively. No doubt, this dual burden of malnutrition presents important challenges for public health policy and systems which need to balance between increasing food availability and reducing the energy density of the diet.

At the household level, the dual burden of malnutrition – a household where at least one member is undernourished and at least one member is overweight – is particularly prominent in countries in the middle income range (Doak, Adair, Bentley, Monteiro, & Popkin, 2005). That members of the same household displaying both under- and over-nutrition is highly paradoxical, especially because socioeconomic determinants (at least at the household level) are essentially the same for all household members. It is explained that the dual burden in the same household is possibly due to age differentials in physiology and nutrition needs (e.g. children need higher per kilogram nutrient than adults), differential susceptibility and potential differences in resources allocation within the household (Tzioumis & Adair, 2014).



Sources: Prevalence of obesity among female adults ages 18 and over was obtained from Global Health Observatory. Percentage of under-fives being stunted was obtained from UNICEF/WHO/World Bank Joint Child Malnutrition Estimates Expanded Database: Stunting, May 2018.
Note: The latest available data for each country were used (1985-2016). The majority of countries (63.3%) have available data for 2010 or after.

Figure 1: Stunting prevalence among children aged 5 years and under and obesity prevalence among female adults aged 18 years and over in Asia

Providing that household food security is closely linked to malnutrition, this raises questions about the implications of climate change on the dual burden of malnutrition. Given robust evidence on the negative impacts of climate change on crop yields , especially wheat, rice and maize (Challinor et al., 2014; Liu et al., 2016), climate variability is likely to increase undernutrition directly through reducing food availability and indirectly though reduced income from agriculture. Primarily relying on rain-fed agriculture, smallholder farmers are particularly vulnerable to rainfall variability. Experiencing a drier than average rainfall is directly associated with food insecurity for small farming households (Niles & Brown, 2017). Deprived of nutritional and caloric needs owing to food insecurity, the natural growth trajectory among children may be jeopardised and may lead to negative health consequences. Indeed, despite methodological limitations and heterogeneities in study designs, a review of 15 studies by Phalkey et al. (2015) pointed to a negative impact of climate (e.g. temperature and rainfall) variability and extreme weather events on childhood stunting at the household level. The climate impacts on children's nutritional status can be long lasting, with evidence suggests that rainfall shocks in utero, for instance, result in lower height when measured during childhood (Thai & Falaris, 2014) and in adults (Maccini & Yang, 2009).

Not only does climate change affect undernutrition, recent literature also link climate change with obesity in two important ways: first, in terms of the contribution of the obesity epidemic to climate change through overconsumption; and second, in the form of impacts of climate change on obesity (An, Ji, & Zhang, 2017). Whilst the former is worth discussing (such as the co-benefits of changing individual behaviour for tackling obesity and mitigating climate change), the latter is more relevant to our focus on the dual burden of malnutrition and climate change. Similar to how climate change affects under-nutrition, a reduction of agricultural productivity, and consequently food supply, due to weather variability can translate into a price shock. As a result, prices of healthy food such as fresh fruits and vegetables become more expensive, prompting households to turn to low-cost, high-calorie foods such as processed foods (Husband, 2013). Although there is no consensus on how obesity is associated with socioeconomic status and dietary choice in developing nations (Dinsa, Goryakin, Fumagalli, & Suhrcke, 2012), low- and middle-income countries have been undergoing nutritional transition where calorie foods and beverages have become cheaper than healthier foods (Popkin, Adair, & Ng, 2012). This implies that less wealthy and less educated households may have more difficulty accessing nutrient-rich foods, especially in time of weather and income shocks. Hence, as a result of climate change, the obesity epidemic may be exacerbated due to the rising cost of maintaining healthy diets.

That climate change may contribute both to under- and over-nutrition is highly paradoxical. It is also fairly complex to explain the dual burden of malnutrition, especially within households. The coexistence of undernourished and overweight or obese individuals within the same household is partially due to differentials in household food allocation. For many countries in South and Southeast Asia such as Indonesia, Bangladesh and India, girls generally receive less energy, carbohydrates and protein than boys (Behrman, 1988; Chen, Huq, & D'Souza, 1981; Wibowo et al., 2015). A similar pattern is reported in China where gender gap in the prevalence in underweight persists through transition from childhood to adulthood (Fu & George, 2015). Under climate change, unequal allocation of food may exacerbate as evidence that households experiencing severe food or unexpected insecurity is more likely to distribute food unevenly across household members (Harris-Fry, Shrestha, Costello, & Saville, 2017). Intra-household inequality in resource allocations may also result in maternal overweight and obesity and child under-nutrition. Higher prices of fibre-rich sources can lead to mothers consuming cheaper energy-

dense foods which are high in calorie but poor in nutrients – insufficient to meet linear growth potential in children. How climate change affects household food allocation will depend on the stage of nutrition transition and how prices of healthy food vary with climatic shocks.

Continuing population and consumption growth coupled with increases in temperature and changes in rainfall patterns pose significant challenges for agricultural production and food security. Projections of climate-induced productivity changes for South Asian countries, for instance, points to a decline of rice, wheat and cereal grains by 4%, 11% and 7%, respectively as of 2030 (Bandara & Cai, 2014). Not only does a decline in agriculture production affect food availability, agriculture itself is also a major source of income for many households (Schmidhuber & Tubiello, 2007). The challenges of the dual burden of malnutrition posed by climate change hence require carefully thought-out policy plans. Improving nutrition through promotion of animal-based protein rich food, for instance, will increase CO_2 emissions which in turn exacerbates climate change. Therefore, not only do the interventions need to simultaneously tackle both under- and over-nutrition, consequences of any policy strategies on anthropogenic climate change should also be considered. This reflects the sustainable development agenda which focuses on addressing multiple challenges to human wellbeing, economic prosperity and environmental sustainability. Considering the synergies and trade-offs between the SDGs thus are central to any policy interventions aiming to tackle the dual burden of malnutrition in the context of climate change.

Recently, co-benefits approaches to health promotion and climate change mitigation have been put forward by the World Health Organization (WHO) and in academia (Haines, 2017; WHO, 2015). Achieving the SDG education targets can significantly support progress towards other targets including health and climate change mitigation and adaptation. There is robust evidence showing that parental education, especially maternal education protects against under-----nutrition (Kumar & Kumari, 2014; Phalkey et al., 2015; Vollmer, Bommer, Krishna, Harttgen, & Subramanian, 2017) and in many cases also over-nutrition (Lakshman et al., 2013; Ruiz et al., 2016). Likewise, recent evidence shows that public investment in universal education has positive externalities in both climate change mitigation and adaptation (Bengtsson, Barakat, & Muttarak, 2018; Chankrajang & Muttarak, 2017; Lutz, Muttarak, & Striessnig, 2014). In confronting the challenges of climate change, prioritising SDG4 on inclusive and equitable quality education may indeed mitigate the impacts of climate change on the dual burden of malnutrition in developing Asian nations.

References

Abdullah, A., Wolfe, R., Stoelwinder, J. U., de Courten, M., Stevenson, C., Walls, H. L., & Peeters, A. (2011). The number of years lived with obesity and the risk of all-cause and cause-specific mortality. *International Journal of Epidemiology*, *40*(4), 985–996. https://doi.org/10.1093/ije/dyr018

An, R., Ji, M., & Zhang, S. (2017). Global warming and obesity: a systematic review. *Obesity Reviews*, *19*(2), 150–163. https://doi.org/10.1111/obr.12624

Bandara, J. S., & Cai, Y. (2014). The impact of climate change on food crop productivity, food prices and food security in South Asia. *Economic Analysis and Policy*, *44*(4), 451–465. https://doi.org/10.1016/j.eap.2014.09.005

Behrman, J. R. (1988). Intrahousehold Allocation of Nutrients in Rural India: Are Boys Favored? Do Parents Exhibit Inequality Aversion? *Oxford Economic Papers*, *40*(1), 32–54.

Bengtsson, S. E. L., Barakat, B., & Muttarak, R. (2018). *The Role of Education in Enabling the Sustainable Development Agenda*. Abingdon, UK and New York, USA: Routledge. Retrieved from https://www.routledge.com/The-Role-of-Education-in-Enabling-the-Sustainable-Development-Agenda/Bengtsson-Barakat-Muttarak-Lutz-Birhanu-Kebede/p/book/9781138307957

Bhutta, Z. A. (2013). Early nutrition and adult outcomes: pieces of the puzzle. *The Lancet*, *382*(9891), 486–487. https://doi.org/10.1016/S0140-6736(13)60716-3

Bredenkamp, C., Buisman, L. R., & Van de Poel, E. (2014). Persistent inequalities in child undernutrition: evidence from 80 countries, from 1990 to today. *International Journal of Epidemiology*, *43*(4), 1328–1335. https://doi.org/10.1093/ije/dyu075

Challinor, A. J., Watson, J., Lobell, D. B., Howden, S. M., Smith, D. R., & Chhetri, N. (2014). A meta-analysis of crop yield under climate change and adaptation. *Nature Climate Change*, *4*(4), 287–291. https://doi.org/10.1038/nclimate2153

Chankrajang, T., & Muttarak, R. (2017). Green Returns to Education: Does Schooling Contribute to Pro-Environmental Behaviours? Evidence from Thailand. *Ecological Economics*, *131*, 434–448. https://doi.org/10.1016/j.ecolecon.2016.09.015

Chen, L. C., Huq, E., & D'Souza, S. (1981). Sex Bias in the Family Allocation of Food and Health Care in Rural Bangladesh. *Population and Development Review*, *7*(1), 55–70. https://doi.org/10.2307/1972764

Dinsa, G., Goryakin, Y., Fumagalli, E., & Suhrcke, M. (2012). Obesity and socioeconomic status in developing countries: a systematic review. *Obesity Reviews*, *13*(11), 1067–1079. https://doi.org/10.1111/j.1467-789X.2012.01017.x

Doak, C. m., Adair, L. s., Bentley, M., Monteiro, C., & Popkin, B. m. (2005). The dual burden household and the nutrition transition paradox. *International Journal of Obesity*, *29*(1), 129–136. https://doi.org/10.1038/sj.ijo.0802824

Fu, Q., & George, L. K. (2015). Sex, Socioeconomic and Regional Disparities in Age Trajectories of Childhood BMI, Underweight and Overweight in China. *Asian Population Studies*, *11*(2), 134–148. https://doi.org/10.1080/17441730.2015.1038873

Haines, A. (2017). Health co-benefits of climate action. *The Lancet Planetary Health*, *1*(1), e4–e5. https://doi.org/10.1016/S2542-5196(17)30003-7

Hanandita, W., & Tampubolon, G. (2015). The double burden of malnutrition in Indonesia: Social determinants and geographical variations. *SSM - Population Health*, *1*, 16–25. https://doi.org/10.1016/j.ssmph.2015.10.002

Harris-Fry, H., Shrestha, N., Costello, A., & Saville, N. M. (2017). Determinants of intra-household food allocation between adults in South Asia – a systematic review. *International Journal for Equity in Health*, *16*. https://doi.org/10.1186/s12939-017-0603-1

Hoddinott, J., Behrman, J. R., Maluccio, J. A., Melgar, P., Quisumbing, A. R., Ramirez-Zea, M., … Martorell, R. (2013). Adult consequences of growth failure in early childhood. *The American Journal of Clinical Nutrition*, *98*(5), 1170–1178. https://doi.org/10.3945/ajcn.113.064584

Husband, A. (2013). Climate Change and the Role of Food Price in Determining Obesity Risk. *American Journal of Public Health*, *103*(1), e2. https://doi.org/10.2105/AJPH.2012.301084

Kumar, A., & Kumari, D. (2014). Decomposing the Rural-Urban Differentials in Childhood Malnutrition in India, 1992–2006. *Asian Population Studies*, *10*(2), 144–162. https://doi.org/10.1080/17441730.2014.902161

Lakshman, R., Zhang, J., Zhang, J., Koch, F. S., Marcus, C., Ludvigsson, J., … Sobko, T. (2013). Higher maternal education is associated with favourable growth of young children in different countries. *Journal of Epidemiology and Community Health*, *67*(7), 595–602. https://doi.org/10.1136/jech-2012-202021

Liu, B., Asseng, S., Müller, C., Ewert, F., Elliott, J., Lobell, D. B., … Zhu, Y. (2016). Similar estimates of temperature impacts on global wheat yield by three independent methods. *Nature Climate Change*, *advance online publication*. https://doi.org/10.1038/nclimate3115

Lutz, W., Muttarak, R., & Striessnig, E. (2014). Universal education is key to enhanced climate adaptation. *Science*, *346*(6213), 1061–1062. https://doi.org/10.1126/science.1257975

Maccini, S., & Yang, D. (2009). Under the Weather: Health, Schooling, and Economic Consequences of Early-Life Rainfall. *American Economic Review*, *99*(3), 1006–1026. https://doi.org/10.1257/aer.99.3.1006

Martins, V. J. B., Toledo Florêncio, T. M. M., Grillo, L. P., Franco, M. do C. P., Martins, P. A., Clemente, A. P. G., … Sawaya, A. L. (2011). Long-Lasting Effects of Undernutrition. *International Journal of Environmental Research and Public Health*, *8*(6), 1817–1846. https://doi.org/10.3390/ijerph8061817

Mazumdar, S. (2010). Determinants of Inequality in Child Malnutrition in India. *Asian Population Studies*, *6*(3), 307–333. https://doi.org/10.1080/17441730.2010.512763

Niles, M. T., & Brown, M. E. (2017). A multi-country assessment of factors related to smallholder food security in varying rainfall conditions. *Scientific Reports*, *7*(1), 16277. https://doi.org/10.1038/s41598-017-16282-9

Park, M. H., Falconer, C., Viner, R. M., & Kinra, S. (2012). The impact of childhood obesity on morbidity and mortality in adulthood: a systematic review. *Obesity Reviews*, *13*(11), 985–1000. https://doi.org/10.1111/j.1467-789X.2012.01015.x

Phalkey, R. K., Aranda-Jan, C., Marx, S., Höfle, B., & Sauerborn, R. (2015). Systematic review of current efforts to quantify the impacts of climate change on undernutrition. *Proceedings of the National Academy of Sciences*, *112*(33), E4522–E4529. https://doi.org/10.1073/pnas.1409769112

Popkin, B. M. (1994). The nutrition transition in low-income countries: An emerging crisis. *Nutrition Reviews*, *52*(9), 285–298. https://doi.org/10.1111/j.1753-4887.1994.tb01460.x

Popkin, B. M., Adair, L. S., & Ng, S. W. (2012). NOW AND THEN: The Global Nutrition Transition: The Pandemic of Obesity in Developing Countries. *Nutrition Reviews*, *70*(1), 3–21. https://doi.org/10.1111/j.1753-4887.2011.00456.x

Ruiz, M., Goldblatt, P., Morrison, J., Porta, D., Forastiere, F., Hryhorczuk, D., … Pikhart, H. (2016). Impact of Low Maternal Education on Early Childhood Overweight and Obesity in Europe. *Paediatric and Perinatal Epidemiology*, *30*(3), 274–284. https://doi.org/10.1111/ppe.12285

Schmidhuber, J., & Tubiello, F. N. (2007). Global food security under climate change. *Proceedings of the National Academy of Sciences*, *104*(50), 19703–19708. https://doi.org/10.1073/pnas.0701976104

Subramanian, S. V., & Kawachi, I. (2007). Income inequality and the double burden of under- and overnutrition in India. *Journal of Epidemiology and Community Health*, *61*(9), 802–809. https://doi.org/10.1136/jech.2006.053801

Thai, T. Q., & Falaris, E. M. (2014). Child Schooling, Child Health, and Rainfall Shocks: Evidence from Rural Vietnam. *The Journal of Development Studies*, *50*(7), 1025–1037. https://doi.org/10.1080/00220388.2014.903247

Tzioumis, E., & Adair, L. S. (2014). Childhood dual burden of under- and overnutrition in low- and middle-income countries: a critical review. *Food and Nutrition Bulletin*, *35*(2), 230–243. https://doi.org/10.1177/156482651403500210

UNICEF, WHO, & World Bank. (2018). UNICEF/WHO/World Bank Group joint malnutrition estimates. Retrieved from http://www.who.int/nutgrowthdb/estimates2017/en/

Vollmer, S., Bommer, C., Krishna, A., Harttgen, K., & Subramanian, S. (2017). The association of parental education with childhood undernutrition in low- and middle-income countries: comparing the role of paternal and maternal education. *International Journal of Epidemiology*, *46*(1), 312–323. https://doi.org/10.1093/ije/dyw133

WHO. (2015). *Promoting health while mitigating climate change* (Technical Briefing for the World Health Organization Conference on Health and Climate). Geneva: WHO. Retrieved from http://www.who.int/phe/climate/conference_briefing_2_promotinghealth_27aug.pdf

Wibowo, Y., Sutrisna, B., Hardinsyah, H., Djuwita, R., Korib M, M., Syafiq, A., … Najib, M. (2015). Relationship between intra-household food distribution and coexistence of dual forms of malnutrition. *Nutrition Research and Practice*, *9*(2), 174–179. https://doi.org/10.4162/nrp.2015.9.2.174