Estimation of main greenhouse gases emission from household energy consumption in the West Bank, Palestine

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ABSTRACT

The main GHGs (CO_2, NO_x, and SO_2) have been quantified based on national energy and population statistics. The results show that the contribution of households' energy consumption in the West Bank to global CO_2 emission is about 0.016%, while contribution of total energy consumption by all sectors is about 0.041%. The results show that wood is the most polluting energy source in terms of CO_2 and NO_x emission, while electricity is the most polluting source in terms of SO_2. Other sources like diesel, kerosene, and LPG that contribute to the GHGs emission are also quantified. The total amounts of CO_2, NO_x, and SO_2 by households in the West Bank are 4.7 million tonne per year, 3.02 thousand tonne per year, and 2.23 thousand tonne per year respectively. This study presents a set of measures that might help in reducing the level of GHGs emission and protect the environment.

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1. Introduction

Energy plays a significant role in economic and social development, and constitutes a major threat to the environment and jeopardises sustainable development. Rapid technological development, improvement in standard of living, and increased population density have increased the concerns over pollutants emission from urban and industrial sources.

Greenhouse gases (GHGs) are chemicals that pollute the atmosphere and cause global warming. Industrial premises, agricultural activities, transport sector, and household activities are the major contributors to GHGs. In Palestine, energy consumption is a major source of air pollution where households are the main energy consumer, with 60% (20,456 TJ) of the total consumption (33,983 TJ) in 2010 (PCBS, 2011b). The residential, commercial, and agricultural sectors consume 43% of the total energy consumption in the Arab region (Abdel Gelil et al., 2011). The residential sector is where a relatively larger proportion of energy is used in the MENA countries. The share of the residential sector in total electricity consumption is

about 65% in Yemen, 56% in Saudi Arabia, 47% in Egypt Jordan, and Lebanon, 40% in the UAE, 25% in Tunisia, and 23% in Qatar (Luciani, 2012). This pattern of energy consumption determines the major sources of GHG emissions, and in many instances, informs policy priorities and measures that will be needed to reduce such emissions. According to estimations developed by the International Energy Agency, global electricity generation was responsible for 44.7% of total emissions in 2010 (13,700 million tonne), making of this sector a key component of any effective measure aimed at mitigating climate change (Abdel Gelil, 2011).

Climate change may be attributed to changes in atmosphere composition that began with the industrial revolution as a result of human activity (IPCC, 2007). Air pollutants from usage of fossil fuel make clouds that reflect more of the sun's rays back into the space. This leads to global dimming, whereby less heat and energy reach the earth. Air pollution occurs because of anthropogenic activities such as fossil fuel combustion, i.e., natural gas, coal, and oil, to power industrial processes, motor vehicles and other household activities. Combustion puts harmful constituents into the atmosphere such as Carbon oxides (CO and CO_2), Nitrogen oxides (NO_x), particulate matter (PM), Sulphur dioxide (SO_2), and volatile organic compounds (VOCs) (Anup, 2005).

EIA (2009) showed that 25% of total GHGs emissions in Greensboro in 2007 were from households. The residential sector

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in the US accounts for 21–22% of both energy consumption and CO_2 emissions (Emrath, and Liu, 2007). The contribution of household energy consumption to GHGs and air pollutant emissions in the Palestinian Territory is a new topic. It's worth mentioning that Palestinians use their homes longer than other countries due to control and restrictions associated with the current political situation. This leads to increased energy consumption through lighting, heating, cooling, and kitchen appliances.

About half of the Palestinian population – mainly in the rural areas, refugee camps, and Bedouins of North and South Governorates – are exposed daily to harmful emissions and other health risks from biomass burning that typically takes place in traditional stoves without adequate ventilation. The majority of individuals exposed to enhanced concentrations of pollutants are women and young children.

Future trends of household energy demand in Palestine are primarily affected by household's type and facility efficiency, urbanisation, and household's economy. The main energy sources in the Palestinian residencies are electricity, diesel, gasoline, LPG, kerosene and fire wood. These are primarily used for cooking, heating, cooling, lighting, and operating appliances (PCBS, 2008a).

This paper aims to analyse and quantify the contribution of household energy consumption to GHGs emission in the West Bank (WB) and to present key measures that play a role in environmental protection.

2. Literature review

No previous studies tried to estimate the GHGs emission from using the different energy sources by the Palestinian activities. However, there is enormous interest in reducing the large and inequitable risks associated with household energy usage in international development and global health. At the international level, there are several studies on the subject as addressed below.

Complainville and Martins (1994) provided evidence on the reductions of NO_x/SO_x emissions induced by the adoption of carbon abatement policies. They described the methodology to compute emissions of these pollutants and the way they were introduced in the OECD green model. Tonooka et al. (2003), based on China's energy statistics, studied the energy consumption of residential housing and analysed in detail by fuel type, urban and rural areas, province, and partly by end use type. Chen et al. (2005) showed a household model for three villages in China where fire wood and coal are the most important energy sources for rural households and analysed the factors that determine the choice of energy source. Tonooka et al. (2006) studied the relationship between income level and priority of energy type use at rural households in the fringes of Xian City. Weber and Matthews (2008) studied residential energy consumption from the standpoint of GHGs emission reduction in addition to the global and distributional aspects of carbon footprint at American households. Kadian et al. (2007) studied the energy-related emissions and mitigation opportunities from the household sector in Delhi. They showed that the use of traditional fuels, like wood, animal waste, and crop residues, in the cities of the developing nations has local environmental impacts due to significant emissions of pollutants such as SO_2, NO_x and CO. They showed that the generation of electricity and use of fuels like LPG and kerosene have global environmental impacts due to considerable emission of GHGs.

Saidur et al. (2007) used a method for estimating the GHGs emission based on daily average usage for the different appliances in addition to the emission factors and fraction of electricity generated by each type of fuel. Anozie et al. (2007) studied the evaluation of cooking energy cost, efficiency, impact on air pollution and policy in Nigeria. Jin et al. (2006) discussed that knowledge

of risk and hazard associated with energy use may exist in forms other than direct linkages with health, including perceptions about how energy use may affect the quality of air inside homes.

Tyler (1996) showed that gains in household income and urban development in many Asian countries have led to significant shifts in household use of fuels. He showed that for electricity use, dramatic increases in household consumption have negative implications for emissions. Kok et al. (2005) estimated the environmental load of household consumption based on input–output energy analysis. Aunan et al. (2009) discussed that the direct effect of absorbing and scattering aerosols on climate is highly dependent on cloud distribution.

According to EPA (2009), despite the efforts and the attention to curb the problem of global warming, GHGs continue to grow. According to EPA (2006), over the past few years, permitting authorities, source owners and operators, and few programs have begun using emissions factors for purposes other than generating a national emissions inventory.

According to UN-HABITAT (2006), cities in developing countries require a rapid increase in energy production and consumption to accelerate economic development, alleviate poverty, and meet the basic needs of their populations. However, energy-related pollution is already negatively affecting human health and living environments, particularly within informal urban settlements. According to IPCC (2006, 2007), changes in the atmospheric concentrations of GHGs can alter the balance of energy transfers between the atmosphere, space, land, and the oceans. A gauge of these changes is called radiative forcing, which is a measure of the influence a factor has in altering the balance of incoming and outgoing energy in the earth-atmosphere system.

3. Methodology

3.1. Study area

The total area of the Palestinian Territory is 6020 km^2 (5655 km^2 for WB and 365 km^2 for Gaza Strip) (Fig. 1). The WB population is about 2.5 millions living in 11 governorates and distributed over three main regions, North (Jenin, Nablus, Qalqilia, Salfit, Tubas, Tulkarm), Middle (Jericho, Ramallah and Al-Bireh, and East Jerusalem), and South (Beit Lehem and Hebron). The Palestinian Authority retained control over some parts of the WB following the Oslo peace accord in 1994. Currently, only 40% of the WB is effectively under Palestinian control while the rest is under the Israeli control. The study does not include the illegal Israeli Settlements established in the Palestinian Territory after 1967. The number of settlers in the Israeli settlements in the WB exceeded 519,000 in 2010, of which 262,493 settlers are living in East Jerusalem (PCBS, 2011a). The GHGs emissions are calculated only for the Palestinian population of the West Bank, excluding the Israeli settlers.

The Palestinian energy sector and all other economic sectors are controlled by Israel, despite existence of a Palestinian Authority. Electricity and the other energy sources, except wood, are imported through Israeli companies and distributed to the Palestinian consumers by national suppliers. The Palestinian energy import represents about 7.3% of the total energy production in Israel (MNI, 2010). The imports of electricity in the Palestinian Territory reached 3865 thousand MWh while production reached 427 thousand MWh most of it from the Gaza Power Plant. The imports reached 512 million litres of diesel, 133 million litres of gasoline, and 122 thousand tons of LPG. Total energy imports in the Palestinian Territory reached 43,147 TJ. Diesel represented nearly 44% of the total energy imports with 18,920 TJ, and electricity represented about 32% of the total energy imports with about 13,913 TJ (PCBS, 2011a).

In 2008, electricity consumption in the household sector summed up to about 15.2 billion kWh, comprising approximately 31% of the total electricity consumed in Israel (MNI, 2010). The domestic sector contributes about 32% of the total electricity consumption during summer peak demands, and about 49% of the total electricity consumption during winter peak demands (MNI, 2010).

3.2. Data source

The basic raw data were collected from the Palestinian Central Bureau of Statistics (PCBS, 2011a,b). The collected population statistics included the number of households, population, and energy consumption in the WB (Tables 1 and 2). The PCBS provided the population data for year 2010 based on the latest national census in 2007 (PCBS, 2008a,b,c,d, 2012). The 2007 population census covered all