Journal of Geography and Regional Planning

Volume 7 Number 3 May 2014
ISSN 2070-1845

Academic Journals

ABOUT JGRP

Journal of Geography and Regional Planning (JGRP) is a peer reviewed open access journal. The journal is published monthly and covers all areas of the subject**.**

Journal of Geography and Regional Planning (JGRP) is an open access journal that publishes high-quality solicited and unsolicited articles, in all areas of Journal of Geography and Regional Planning such as Geomorphology, relationship between types of settlement and economic growth, Global Positioning System etc. All articles published in JGRP are peer-reviewed.

Contact Us

Editorial Office: jgrp@academicjournals.org

Help Desk: helpdesk@academicjournals.org

Website: http://www.academicjournals.org/journal/JGRP

Submit manuscript online http://ms.academicjournals.me/

Editorial Board

Journal of Geography and Regional Planning

Table of Contents: Volume 7 Number 3 May 2014

ARTICLES

Research Articles

academicJournals

Vol. 7(3), pp. 36-46, May, 2014
DOI: 10.5897/JGRP2013.0391
ISSN 2070-1845

http://www.academicjournals.org/JGRP

Journal of Geography and Regional Planning

Full Length Research Paper

Governance of agriculture in the cities of developing countries: Local leaders' perspectives

Hawa Suleiman Mkwela

Department of Geography Norwegian University of Science and Technology (NTNU) Norway.

Received 12 June, 2013; Accepted 15 April, 2014

This paper used the perceptions of local leaders at a ward level to assess the governance of urban agriculture (UA) in Kinondoni Municipality-Dar Es Salaam City in Tanzania. Unstructured interviews were conducted with 24 local leaders involved in the day to day governance of UA in the Municipality. During the interviews, the local leaders were requested to narrate their perceptions on the governance of UA in the Municipality based on three criteria namely leadership quality, infrastructure provision and farmers' land right. In general, the leaders had the opinion that in the current settings there were limited efforts and plans to support UA in Kinondoni Municipality as assessed using the three criteria mentioned above.

Key Words: Governance, urban agriculture, local leaders, ward agricultural officers, Tanzania

INTRODUCTION

Urban agriculture (UA) has been known to be both a strategy for dealing with poverty and a means to ensure sustainability (Mlozi, 1997, Foeken, 2005). On the contrary, improperly practiced UA can be a source for environmental degradation, pollution and health hazards (Mlozi, 1997; Sawio, 1998; Mvena, 1999).In Tanzania, UA is construed to mean the carrying-out of plant and animal husbandry activities within statutory townships boundaries as provided in the schedule of the town and country planning (urban farming) regulations, 1992. The definition, however, does not identify delimits for the term 'townships'. For example it is not clear if the term covers those intensively developed areas alone or it also annexes sparsely developed peri-urban areas (Schmidt, 2011 and Mwalukasa, 2000). The following sections of the introduction cover the history and reasons for existence of UA in the least developing countries, the conflict between policy and/or legal positions versus urban farmers positions as well as the major issue dealt with in this paper.

Setting the ground: UA in developing countries

In many developing countries UA is considered to be a nuisance and at times an illegal activity (Bryld, 2003; Mlozi, 1997; SCINAP, 2011a). On the contrary, pressures from urbanisation, economic constraints and lack of formal means of employment had forced the majority of the urban dwellers to participate in UA defying these legal provisions (SCINAP, 2011a; Foeken et.al, 2004; Rakodi, 1988, Yeung, 1988 and Diallo, 1993; Mlozi, 1997). Data for people engaged in UA in Tanzania varies significantly, for example Mvena (1999) estimated that 80% of the

*Corresponding author E-mail: hawa.mkwela@svt.ntnu.no Tel: +4740570404

urban dwellers are involved in UA while the census briefs (2003) and (2012) had estimated it at 14%. While it is difficult to explain the enormous variations between the two data sets; it can inferred that the size of the sample used in the studies had an influence in the overall results. The census is based on the wider survey of the people in all urban areas in Tanzania while Mvena (1999) had studied urban residents in the City of Dar es salaam alone.

It has been estimated that in the 1990s many households in the least developing countries (LDC) spent up to 80% of their average income on food (Ethelston, 1992). This spending pattern escalated their adoption of UA as alternative source of both income and food (Foeken et.al, 2004; Mvena, 1999). As such, urban dwellers use UA as a strategy for survival and thus they consider any legal provision against it to pose an eminent danger to their livelihoods (Mbiba, 1994; Mvena, 1999; Briggs and Mwamfupe, 1998 and Schmidt, 2011).

There are evidences to substantiate the claim that at the national level UA in Tanzania is a reasonably supported (SCINAP, 2011a; URT, 2000). Whether the practice is receiving full support from the central government or not is a cause for debate. For example some researchers such as Foeken et al, (2004) noted that the ministry of agriculture and food security (MAFS) uses its urban based agriculture/livestock extension agents (ALEAs) to promote UA (Foeken et al, 2004). This is contrary to Sawio (1998) and Schmidt (2011) who pointed out that there is no organisation at the ministerial level used to promote the existence and sustainability of UA. Also, at the city level, studies have shown that it is illegal to have land measuring more than 3 acres for growing food and that farming is not part of the functions within any urban area (Sawio, 1998; Mwalukasa, 2000; Mvena, 1999; SCINAP, 2011a). Due to non-integration of UA in the town planning process, there has been a number of infrastructural, social and environmental constraints despite its economic potentials.

In Kinondoni (one of the three municipalities forming the city of Dar Es Salaam); UA is partly recognised as a legal activity. The evidence to support the semi-legal status of UA activities in Kinondoni Municipality include; (1) The municipality has set aside land for UA in Kawe, Uzuri-Manzese (demonstration gardens) and along River Mpiji in Bunju Ward, (2) Almost each ward (both rural and urban) is allocated with an extension officer to oversee agricultural activities, (3) Farmers receive financial support and implements through district agriculture development programs (DADPs). Schmidt (2011) estimates that around 60% of land in Kinondoni are under cultivation and produce about 7% of the total food requirements. This shows that the level of UA productivity is lower compared to the amount of land in use in the municipality.

The issue and the gap

The Issue: The support extended to farmers as well as the existence of some by-laws governing UA (Sawio, 1998; Foeken, 2005; Schmidt, 2011) shows that UA is important and accepted. However, the reality on the ground is different, UA is haphazardly practiced by small-scale farmers without substantive plans to promote, coordinate, guide and safeguard farmers' access to land and the ensuing rights, ensure sustainability and encourage productivity by providing the necessary infrastructure (Sawio, 1998; Mwalukasa, 2000; Mvena, 1999). Small-scale UA farmers in Kinondoni municipality argue that poor governance and even corrupt officials are the sources of their ever compounding woes.

The gap: Past studies in urban agriculture in Dar Es Salaam city or Kinondoni municipality in particular have concentrated and dealt with issues such as legal and policy (Foeken, 2005; Schmidt, 2011); Livelihoods (Sawio, 1998); benefits of UA to farmers (Jacobi et al, 2000; Sawio 1998; Schmidt, 2011; Mlozi, 1997) and Institutionalisation of UA in the environmental planning and management (EPM) process (Mwalukasa, 2000; Mlambo, 2002). Evidence from literature has shown that little has been documented on the governance of UA in Dar Es Salaam City and particularly in Kinondoni municipality (for example, Mwalukasa, 2000). Similarly, the revised studies concentrated on the farmers, plans and policies leaving aside the group of actors (local leaders) which is at the heart of promoting and coordinating the practice. These leaders are the connecting bridge between the farmers and the government. Their ideas may form a base for the formulation of farmers' friendly policies, by-laws and plans for UA practices in Kinondoni and the whole of Dar es Salaam. This is augmented by Schmidt (2011); who argued that the role to initiate efforts to promote or protect UA lies with the local leaders. Do these leaders heed to that role?

This paper intends to fill that gap by assessing the local leaders' perceptions on the governance of UA in Kinondoni municipality. The research on which this paper is based intended to assess local leaders knowledge on the governance of UA based on the three criteria of leadership quality, infrastructure provision and farmers' land rights. Local leaders within ward offices are important actors in the governance of the functions of both local and central government. They represent the arm of the government which administers the day to day functions at the second lower level in the administration hierarchy in Tanzania.

In this paper, the title local leader is used to represent officials working in the ward offices and specifically the ward agricultural officers (WAOs) and in their absence the ward executive officers (WEOs) or ward livestock officers (WLOs). WAOs are government officials charged with the responsibilities to coordinate, promote and oversee UA activities within their jurisdiction that is, wards. In their intermediary role, WAOs are in constant interaction with both the farmers in the field and policy makers on the decision making end at ward, district and municipality levels. Thus, their understanding of issues surrounding governance of UA reflects both field experience and policy positions. In their absence, the WLOs and WEO assume their responsibilities.

Governance: The state, the power and the influence

The idea of good governance originates from the restoration of the government as a key actor in economic and political development (Grindle, 2010; Kjær, 2004).There are many definitions of the term governance depending on the use, need and perception of the person(s) or organisations involved; a common consensus is yet to be reached (Kjær 2004, Pierre and Peters 2000, Jreisat, 2002, Kaufmann et al., 2010). The world bank (1992) regards governance to be "the manner in which power is exercised in the management of a country's economic and social resources for development".On the other hand international monetary fund (IMF) defines governance as "the broad concept which encompasses all aspects of the way a country is governed; including its economic policies and regulatory framework, as well as adherence to the rule of law". While the African development bank (AfDB) has the view that governance is "a process referring to the ways in which power is exercised in the management of the affairs of a nation", the united nations development programme (UNDP) defines governance as *"the exercise of economic, political and administrative authority to manage a country's affairs at all levels*". The paper adopts the definition by UNDP, which links the relationship between economic, political and administrative authority in dealing with all affairs within a country at all levels. WAOs are administrative leaders at ward level entrusted with the authority to promote and oversee the day to day functions of the farmers within their jurisdiction. They act as a bridge between the grass root actors-*farmers* and actors at the policy marking tier-*administrative officials and/or politicians*. This position gives them an advantage of understanding farmers' woes as well as policy issues and positions. In their position WAOs may influence both farmers and policy in ways of devising appropriate strategies and policies to deal with UA in the municipality. Thus, the use of WAOs in assessing the governance of UA in Kinondoni is founded on the need to have a group of individuals who are likely to provide a fair assessment without taking sides.

Criteria for the evaluation of UA governance in Kinondoni municipality

In evaluation studies it is important to first set the benchmarks or points of reference which may be used to test and verify the studied issues. Therefore the study had to establish these criteria based on the existing literature. Thus, literature in UA in Tanzania and Kinondoni in particular were revised and repeating issues were noted. These issues were then captured into thematic areas. After collation and pattern matching three criteria were identified. Under each of the criteria, there were a string of factors which tends to define the success of the criteria as shown in Table 1. Table 1 has identified the common criteria which appeared in some of the UA literature accessed by the researcher. These criteria are discussed in the following sub-sections:

The Leadership Quality: The leadership quality is concerned with the availability of visionary administrative machinery intended to create an enabling environment for the proper operationalisation of the UA activities (Rakodi, 1988; Sawio, 1998). The general premise is that; strong and visionary leadership at local and central government is very important for the promotion, regulation and sustainability of UA activities (Mwalukasa, 2000; Schmidt, 2011; SCINAP, 2011b). The unconditional support of the planners, decision makers, local leaders at different levels in securing resources for UA is vital for the formalisation of UA (Sawio, 1998). A good leader ensures that all factors relevant for sustainability of UA activities are well-functioning (SCINAP, 2011b; Sawio, 1998). Leadership is expected to plan, organise and co-ordinate the UA practice to ensure efficiency and productivity by ensuring availability of infrastructure and access to land (Schmidt, 2011, Foeken et al, 2004; Mlambo, 2002; Mwalukasa, 2000). Thus, it is only fair to assess the leadership quality based on the availability of plans for UA practice, regulation of the activities and efforts to avail the needed agricultural infrastructure such as roads, markets, irrigation, storage and micro-financing (SCINAP, 2011b). In absence of good leadership, UA will be misguided or un-directed. This will be a good platform for unscrupulous officials to intentionally deter or delay any efforts to provide the necessary plans and infrastructure.

Provision of infrastructure: Availability, functionability, accessibility and affordability of infrastructure are vital in the operation of UA activities (Schmidt, 2011; Sawio,

Table 1. Identification of criteria and critical success factors

Criteria	Critical success factors	Sources of information
The Leadership Quality	Availability and implementation of plans for sustainable UA Regulation of UA Efforts to avail the needed infrastructure	Sawio, 1998; Mwalukasa, 2000; Foeken et.al, 2004; Rakodi, 1988; SCINAP, 2011a;Schmidt, 2011; Mvena, 1999.
Provision of Infrastructure	Availability Affordability Accessibility Functionability	Schmidt, 2011;Sawio, 1998; Foeken et.al, 2004; SCINAP, 2011b, Mvena, 1999.
The Farmers' Land Rights	Availability of land and/or land use plans for UA Access to land Security of tenure	Sawio, 1998; Mwalukasa, 2000; Foeken et.al, 2004; SCINAP, 2011a, Mvena, 1999; Schmidt, 2011.

1998; Foeken et al., 2004; SCINAP, 2011b, Mvena, 1999). The basic idea here is that the governing authority should be involved in the process of providing the necessary agricultural infrastructure such as, boreholes and tape water which can be used for irrigation (*availability*). The infrastructure should be accessible by all the urban farmers within the area without discrimination or unnecessary conditions within agreeable terms (*accessibility*). The terms should consider abilities of the users in terms of economic powers (*affordability*) and the infrastructure should be functioning at full range without interferences and/or break-downs (*functionability*).

In order to ensure productivity and sustainability of UA, the availability and functioning of basic infrastructure such as water, market, storage facilities and extension services cannot be over-emphasised (Sawio, 1998; Foeken et.al, 2004). For example Sawio (1998) noted that while the tap water distributed by the Dar Es Salaam water supply company (DAWASCO) is easily accessible by urban farmers has tended to be expensive and unaffordable. Farmers have thus resorted to using polluted and not fit for human consumption water from rivers such as Msimbazi River (Sawio, 1998; Kiango, 2010). At times, Foeken et al (2004) argued that due to scarcity of tap water, DAWASCO has disconnected the supply used by farmers to irrigate their produce (*un-functionability*). The disconnection of tap water has led to the killing of the farmers' produce. In the case of accessibility, Dongus et al. (2009) had found that only 30% of the urban farmers in their sample were using tap water; while slightly more than a half were not irrigated or relied on rainfall or open wells water.

The availability, affordability, functionability and accessibility of these services are the criteria for the evaluation of the achievement of the governance of UA in Kinondoni municipality. In order to provide a fair analysis, the study also looked into the availability of plans intended to provide each of the mentioned infrastructure.

The farmers' land right: The farmers' land right is concerned with availability of and accessibility to the formal land by the urban farmers (SCINAP, 2011; Schmidt, 2011; Mwalukasa, 1999). It also involves protection of the existing parcels of land used by the farmers against other land uses and future plans to designate land for urban agriculture (Mvena, 1999; Mwalukasa, 1999). Schmidt, 2011 argued that municipal officials often fails to see value in Agriculture and believe that residential or industrial land uses are superior and would generate more revenue. Thus, they tend to have little interest in protecting agricultural land. There is an agreement that municipal official and urban planners have continually failed to incorporate agriculture into planning process. This was also observed by the land policy, 2000; which stated in its item 4.3 that the relevant authority has failed to designate and allocate land for UA and that as the urban areas expand, agricultural land is lost to other land uses. In evaluation of the farmers' land right, the study used criteria such as availability of land, access to land, security of land tenure and existence of UA land use plans in Kinondoni municipality.

RESEARCH APPROACHES AND METHODOLOGY

The study area

Kinondoni municipality Kinondoni is the second largest Municipality in Dar Es Salaam City-Tanzania with a total land mass of 531,000 hectares and inhabited by 1,088,867 people making it the highly populated municipality in the whole country. It has 39,980 ha of

land favourable for UA, which is about 7% of its total area. According to the information from Dar es Salaam city council, there are about 197,500 farmers tilling around 13,600 ha which means around 66% of the arable land is idle. Agriculture is estimated to contribute 7% of the total required food in Kinondoni Municipality (Schmidt, 2011). Kinondoni is divided into 4 administrative divisions and 27 wards. 20 of those are urban wards and the remaining 7 are rural. Nevertheless, the rural wards in Dar es Salaam mainly exhibit the characteristics of the urban fringes.

The choice of the study area

The choice of Kinondoni as a case study is based on a number of factors; First, Kinondoni has been in the fore of legitimising the UA in the city of Dar Es Salaam. Its efforts coupled with the assistance of sustainable cities international network-Africa program (SCINAP) have partially borne fruits and plans for the inclusion of UA in its master plan are now on the verge of being approved (SCINAP, 2011). Equally important, Kinondoni has been chosen due to its population challenges; the municipality is the most populated in the whole country. Kinondoni therefore is a good case study for evaluation of the governance of UA practices in Dar Es Salaam and Tanzania as a whole.

UA governance in Kinondoni: Localised practice versus centralised policies

In Kinondoni Municipality as it is the case for other parts of Tanzania, UA is practically governed at the municipal and ward levels (Schmidt, 2011). At the Municipal level, there is Municipal agricultural and livestock development officer (MAOLD) who oversees the promotion, coordination and management of the agricultural activities. At the Ward level, there are WAOs with the same responsibility. In case there are no agricultural officers, the WEOs take charge of the governance of UA in a particular ward. On top of the three responsibilities mentioned above, the WAOs are responsible for provision of extension services to farmers in the ward, and to respond to any emergency issues such as floods, animal/insect attack and others. The WAOs are also required to submit a monthly agricultural development report to the MAOLDs. In the report, they are required to provide details on the amount of rainfall, amount of produce, number of farmers they have visited, available farm implements, the level of demand for farming implements, repair of equipment and weather challenges. Interestingly, it could be noticed that the report is more on the farm implements and weather issues; some of the farmers' challenges, such as land rights, irrigation, marketing and plans for sustainable UA are conspicuously missing out. Further, the reports produced by WAOs are local in nature and reflects a condition on the ground within a specific ward.

However, policies and laws affecting UA are formulated at the higher level (that is, the ministry of lands, housing and human settlements development and the ministry of agriculture and food security). These policy makers seem to lose touch with the reality on the ground (Foeken et al, 2004; Mvena, 1999; Mwalukasa, 1999; Sawio, 1998). The outcome has been the formulation of the policies, which work against the farmers and the farming as a whole as discussed earlier on (Rakodi, 1988). This has complicated the day to day functions of the WAOs and MALDO sat ward and municipal levels. For example, in recent times, the ministry of lands housing and human settlement development (MLHHSD) has declared that there are no farms in Dar es Salaam. This government order prohibits the granting of the right of occupancy to people who own farms within the city boundaries. This order coupled with the policies, which were discussed in the previous sections made it easy for the acquisition of the farming land for the urban uses.

Approaches in data collection and analysis

The study intended to respond to questions with the nature of *why*, *how* and *what* with the view of extracting meaning from the opinion of the local leaders who are involved in the day to day promotion, coordination and management of UA in Kinondoni Municipality. These questions according to Yin (2009) are within the post-positivists paradigm and are best answered using the qualitative approaches. One of the major data techniques used in data collection in qualitative studies is narrative approach, which was the main data collection tool in this study. The leaders narrated their experience and knowledge based on the criteria identified in Table 1 above.

Sampling and Data Collection

There are 27 wards in Kinondoni Municipality with 27 local leaders (one at each ward) who are responsible for coordination, promotion and management of agricultural activities. Out of 27 leaders, the study managed to hold interviews with 24 leaders; this is 89% of the study population. The study interviewed 6 respondents from the rural wards and 18 from the urban wards. The sample is a good representation of the population as only 3 leaders were not reached. The results from the study strongly reflect the perceptions of the majority of local leaders in Kinondoni Municipality. A total of 21 WAOs and3 WEOs were interviewed.

The interviews were requested a week or two in advance. Mobile telephone played a great role in setting appointments with the leaders. The leaders' telephones numbers were obtained from Kinondoni Municipality website. Notwithstanding, the fact that the meetings were pre-arranged, holding the interviews was not easy. Some meetings were rescheduled at the last minute while for others it took up to three visits and reminders. Most of the time, the local leaders were busy attending other matters in relation to the ward development or their own personal chores. The narratives from the interviews were qualitative in nature. The instruments used had 12 thematic questions and local leaders were requested to narrate their understanding and knowledge over the UA governance issues based on the criteria leadership quality, provision of infrastructure and farmer's land rights (Table 2). During the interview local language (Kiswahili) was used for clarity and ease of communication.

Data analysis

The data analysis was intended to establish the patterns which can be used to discriminate and discern the status of governance of UA in Kinondoni Municipality. The analysis was based on pattern matching (Yin, 1984; Maxwell, 1998; Stewart, 2000, Powel and Renner, 2003 and Oliver, 2004). Pattern matching involves the comparison of the empirically observed pattern(s) against a predetermined or predicted pattern or situations. The purpose was to determine the level of agreements or disagreement between the WAOs on the issue under evaluation based on majority decision-criterion. In the urge to ensure uniformity of the assessment percentages were adopted to indicate the degree or level of agreement

Table 2. Criteria, critical success factors and thematic questions

Criteria	Critical success factors	Questions
The Leadership Quality	Availability of plans for sustainable UA	1 Some people are arguing that there are no plans for sustainable UA in the Municipality. What is your opinion on this matter?
	Regulation of UA	2. Some people are saying that at the moment urban agriculture is not properly regulated. What is your opinion on this matter?
	Efforts to avail the needed infrastructure	3. Some people argue that the government is not doing enough to ensure availability of infrastructure for UA. What is your opinion on this issue?
Provision of Infrastructure	Availability	4. Some people are of the opinion that necessary UA infrastructure are not in place. What is your opinion this issue?
	Affordability	5. Some people are arguing that the necessary UA infrastructures are not affordable by the urban farmers. What is your opinion on this matter?
	Accessibility	6. Some people are of the opinion that the existing UA infrastructures are not accessible by the urban farmers. What is your opinion on this issue?
	Functionability	7. Some people are of the opinion that the existing UA infrastructure are not properly functioning. What is your opinion on this?
The Farmers' Land Rights	Availability of land and/or land use plans for UA	8. Some people are of the opinion that land for are not available/designated. What is your opinion in this matter?
		9. Some people argue that there are no land use plans for UA in the Municipality. What is your opinion on this matter?
	Access to land	10. Some people are of the opinion that farmers' access to land is limited. What is your opinion on this issue?
	Security of Tenure	11. Some people are of the opinion that in the current environment farmers have no secure tenure. What is your opinion on this matter?

or disagreement among the local leaders. In this, study the patterns established from WAOs' responses were compared to critical success factors (CSF) summarised column 2 in Table 2. This is a tedious but a reliable way of establishing the facts related to phenomenon under evaluation in a qualitative bases. It mainly depends on the logical and sensible interpretation of the transcription by the researcher (Yin, 1984). Data analysis involved three simplified stages; (i) transcription of the interviews (ii) observation of the patterns (ii) making sense and matching of the patterns to CSF. The use of qualitative approaches in analysing data was important since the number of respondents was below 30 units which is a reasonable sample for quantitative analysis.

RESULTS AND DISCUSSION

This section reports and discusses the results of the evaluation of the governance in Kinondoni Municipality based on the identified criteria.

Assessing the leadership quality

Availability of plans for sustainable UA: The local leaders in Kinondoni are aware of the efforts to formalise UA in the Municipality, which are mainly pioneered by foreign non- governmental organisations (NGOs) such sustainable cities international network-Africa programme (SCINAP). Majority of the leaders, however, are of the opinion that these plans are not meant to sustain UA and may not be achieved within the next few years. Around 46% of the interviewed local leaders believe that the plans for sustainable UA in Kinondoni may not be realized while around 37% thought the plans can be achieved. The remaining 17% was equally divided between those leaders who were undecided and not sure if the plans are sustainable or could be realised within the next few years. The first category of leaders have the opinion that these plans have been in place for years since the inception of the Dar Es Salaam sustainable cities project (SDP) in the early 1990's without much success on the ground. The SDP was launched in 1992 had the aim to plan and manage growth of the city in partnership with interested groups of stakeholders, including urban farmers (Mwalukasa, 1999). But the leaders observed that the SDP closed shop in the late 2000's without solving issues of land access and tenure to urban farmers. This was also echoed by Foeken et al (2004) and Mvena (1999). On its part, SCINAP has been involved in the provision of awareness and public sensitization on the

need of incorporating UA in the master plans. However, their efforts are being frustrated by irresponsive local leaders (SCINAP, 2011).

Regulation of UA Activity: UA as an economic activity is not formally regulated. The leaders are of the opinion that the campaigns used by the municipal administration are ad-hoc and mainly against the farmers' interest. Over 76% of the leaders agree that UA is haphazardly practiced and farmers tend to initiate their own plans for land acquisition, marketing, farm implements and irrigation. Non-regulation of the market has led to insecurity of tenure, unreliable markets, poor marketing strategies and dependency on rain and/or polluted water. The results reflect the earlier observations by Sawio (1998); Foeken et al (2004); Schmidt (2011) who have shown that UA is not regulated in Dar es Salaam. For example Sawio (1998:12) noted that *"Urban planning regulations do not clearly permit urban agriculture activities and by-laws that are formed to guide UA activities are not clearly understood by all practitioners"*. Lack of appropriate ways of controlling UA has led to the use of unsafe irrigation water (Mwalukasa, 1999; Sawio, 1998), invasion of hazardous land (Sawio, 1998; Foeken et al, 2004). On the other hand, 20% of the local leaders were of the opinion that the practice is partially regulated taking examples of policies which limited the size of land to be owned by urban residents (Mwalukasa, 1999 and Mvena, 1999 and Mlozi, 1997). This group further argues that the Municipality administration is now working closely with the foreign NGOs and local farmers groups. The remaining 4% were not sure if UA is regulated or not.

Efforts to avail the needed agricultural infrastructure: It has been revealed that local leaders are of the opinion that UA can be effective if the necessary infrastructure such as markets, irrigation systems, transport networks and storage are in place or the government works hand in hand with the farmers to ensure their availability, access and reliability. Around 87% of the local leaders agreed that these infrastructure systems are vital for the sustainability of UA. While 6% had the opinion that the government had supported the farmers in terms of infrastructure provision through its programs such as DADPs. Majority of the local leaders (84%) have the opinion that the government has done nothing in terms of infrastructure provision.

Allocation of and/or safeguard of the farmers' land: Local leaders are also assessed based on their abilities to ensure availability of and/or safeguarding land used by farmers. The evidence has shown that 90% of the local leaders in Kinondoni agree that the government has not played its role in the provision and/or safeguarding farmers' land. One of the local leaders noted that the land that was formerly allocated to farmers along river Mpiji has been converted into a dumping site and sand mining areas without government interventions. This has reduced the amount of land intended for agricultural purposes. The remaining 10% was divided equally between those who believe that the government had assisted farmers and those who were not sure.

Assessing the provision of infrastructure

Availability, Affordability, Accessibility and Functionability of the Infrastructure: Infrastructure has been identified to be vital for the sustainability of UA. The important infrastructure includes markets, irrigation systems, transport networks and storage. Local leaders were requested to identity the availability, reliability, functionality and accessibility of each of the mentioned infrastructure.

Generally, local leaders agreed that majority of the above infrastructures are not available in areas where farming is conducted. 94% of the local leaders are of the opinion that there are market facilities, reliable road networks, irrigation systems or storage to ensure that perishable goods are kept fresh. The remaining 6% noted the fact that the government has in some areas provided these infrastructures either for general use or specifically for UA. However, they agree that the infrastructures are now in a bad shape and in want of repairs. Lack of infrastructure has been discussed in length by Sawio (1998).

There were a number of issues related to the availability, accessibility and functionability of water infrastructure resources. According to Sawio (1998) and Schmidt (2011) farmers have been using water from Msimbazi valley, which is highly contaminated with heavy metals such as cadmium, lead and copper well above the allowable national and international levels. Sawio (1998) proposed for technology for harvesting water, digging of small reservoirs, shallow wells and even the use of pumps. However, a simple analysis of each of the proposed alternatives reveals that farmers require a seed capital. The question of capital is not easy to urban farmers who have no access to any micro-financing. Thus, the propositions are both unaffordable and thence inaccessible to the urban farmers.

Marketing of the farmers' produce is essential in ensuring the need for the UA to serve as a source of income/employment. Due to the perishable nature of the crops produced in Kinondoni the farmers should be ensured with a market place. The interviews with the local leaders have shown that around 92% of the respondents admit that in their wards there are no markets for UA

Plate 1. Farmers preparing the merchandise

Plate 2. The use of advertisement

produce. Only 4% of the respondents said they have markets and the same percent had no answer regarding this question. The leaders further identified poor packaging; low prices of the produce and transportation issues (normally dependence on hired vehicles at higher tariffs) to be among the issues negatively affecting the marketing of their produce. Lack of market (which was also discussed by Mvena, 1999) within the wards, limits the income from UA produce; farmers rely on street peddling, or on-site selling or formal markets in other areas as their selling points. This is costly in-terms of resources and time used to attend to customers or move the products to the nearby market. Plate 1 and 2 shows marketing strategies by farmers in Kinondoni municipality.

Transportation of produce to the market: Lack of market facilities within farmers' vicinity has prompted them to transport their produce to the nearby local market or customers. There are various ways used to access the customers or market as identified by the local leaders. 65% of the local leaders asserted that, transportation of the produce is normally done on foot. Farmers use locally made baskets to carry their produce. They will stroll the street peddling and touting the customers or just walk silently to the market. Others identified the use of bicycle (8%); bus (4%); combination of bus and bicycle (4%); combination of on foot and bicycle (10%) and the combination of bicycle, tricycle (Bodaboda), bus and on foot (9%). The overall lesson from this observation is that UA is practiced mainly by people who seldom can afford ownership or the use of car (plate 3 and 4). This is supported by the evidence that around 50% of the respondents asserted that low income earners are the major participant in UA. The means of transport used also indicate that farmers are only able to sell limited quantities of crops.

Assessing the farmers' land rights

The effectiveness of UA activities depends on the availability and accessibility of land. The farmers' right to land ensures continuity in the practice and possibility of receiving supports from financial institutions and international organisations. Local leaders were requested to give their opinion regarding the availability of land for UA or land use plan(s), access to land and security of tenure. The following sections account for the results from local leaders regarding the land question.

Availability of land and of UA land use plan(s): UA activities in Kinondoni are now allowed in four main locations mentioned earlier. Kinondoni Municipality has designated an area of 5 hectares of land for UA activities along River Mpiji. There are also other areas allocated for UA such as Kawe, Malolo and Uzuri-Manzesegardens.
The amount of land allocated to UA in the four areas is small compared to the number of people involved in UA in the Municipality. The available data have shown that a total of 50,400people are currently actively involved in UA as their main source of income. 78% of the local leaders pointed out that UA is a localised activity, which requires space/ land to be availed at ward level. Only 2 wards out of the 27 have been allocated with a limited amount of land for UA activities. At the moment, leaders agree in Majority (93%) that, the government has not done enough to ensure availability of land to urban farmers. The Leaders in Kawe and Mpiji wards pointed out that the available land was not intentionally intended for UA but it

Plate 3. Farmer transporting a sack of maize (source: Maisha Plus)

Plate 4. photos showing marketing of UA produce

was a spill-over. In Kawe, the land was intended to be a teaching farm for people involved in horticulture. While in Mpiji, it was a leftover of a 20,000 plots delivery project (PDP).

In terms of plans, 92% of the local leaders had the opinion that the government has no specific land use plans for UA while around 6% had used Kawe and Mpiji areas as examples of available plans. The remaining 2% were not sure about the availability of plans. The local leaders along river Mpiji had accounted that; there were many plans for agricultural development along river Mpiji prior to 20,000 PDP. They narrated further that the 20,000 PDP has taken land set aside for agriculture and leave behind a small amount of land which it deemed to be hazardous. This reflects the earlier observation by Sawio (1998:8) that *"as the urbanisation proceeds, space demanding forms of UA migrates to more peripheral or less valued locations".* The situation in Dar Es Salaam is becoming worse as almost the whole city has expanded to the limits on its northern boundary.The leaders lamented that the 20,000 PDP had allocated plots for re-sidential use along the river banks. The on-going con-struction has impacted on the quality and amount of water used for agricultural activities. This sentiment was equally shared by the ward leaders at Mbweni, Goba, Bunju and Mbezi.

According to the local leaders, land that has been alienated by the 20,000 PDP was prime for the UA activities.

Apart from the two agricultural projects implemented at river Mpiji and Kawe garden the study has identified that UA is taking place in areas which are set for other activities. UA is taking place mainly along the rivers, un-developed plots, open spaces, housing yards and road reserve. Around 46% of the respondents informed the study that UA takes place along the river while 21% pointed housing yards to be popular. Open spaces and undeveloped land were in the third position with a score of 12.5% each. It was noted that 8% of the respondents identified road reserve as another area in which UA is conducted. Unlike in some other areas, farmers along road reserve are mainly involved in the flowers and plants nurseries. The evidence has shown that 84% of the leaders are of the opinion that farmers in rural wards own up to 5 acres of land while those in urban ward own between half an acre to 2 acres. The leaders noted that the size of the land depends on availability of the land and farmers purchasing power.

Management of the land used for UA is thus mainly effected by the farmers themselves; except in those areas which are legally designated. In these areas, the local leaders are involved in the distribution and over-seeing the UA practices in collaboration with the farmers' group leaders.

How do Farmers Access Land? : The local leaders agreed that, most of farmers access land in an informal way except in a few designated areas along Mpiji River and Kawe gardens. The leaders pointed out that in planned areas UA is practiced on the land originally designated for residential use, commercial use, industrial use which are not developed yet or open spaces. The main way of accessing land in these areas is through grabbing. Farmers; individuals or groups will invade or encroach into land which has been idle or planned for other land use.

In rural wards, farmers mainly buy land from the traditional/customary land owners. 21% of the local

leaders in rural areas reported that, mainly farmers own land in customary way and farming is not restricted in their wards. Also, another 21% of the local leaders noted that farmers would utilize idle land as a means of protection against invaders/encroachers. In this arrangement farmers enter into an agreement with the farm/plot owners (who are not residing in the rural wards) to temporarily till the land. In this case, farmers are formally recognised by the owner in exchange for protecting the land from land invaders. This is a win-win situation, because the farmer will be allowed to use the land while the owner will be sure that his/her land is protected.

Generally, looking from outside one would assume that there is no specific arrangement for the land used by urban farmers. On the contrary, agricultural activities are regulated in an informal manner. For example, open space farming in the rural wards is more tolerated than in the urban wards. In the urban wards, most of farmers have agreements with some authorities that own undeveloped land such as army, universities, The Tanzania electrical company and schools. This type of agreement does not protect the farmer when the authorities decide to utilize their land for other purposes. Mainly the agreement is temporary and it can be terminated at any time. This is the case for example when there is a new leadership or change of institutional plans over the land. In the urban wards, 55% of the leaders admitted that farming is not allowed in their wards and farmers only utilize open spaces and their household plots to create small gardens.

Security of Land Tenure: Security of land tenure has been a major concern of the local leaders. Over 90% of the leaders asserted that farmers have no legal ownership over the land in areas where UA is practiced. Around 6% of the leaders argued that farmers have legal rights over their land. The two areas where farmers have been deemed to have legal rights are Mbweni and Kibamba, along Mpiji River. These areas have been designated by the Kinondoni Municipality for present and future UA activities. However, according to the officials in the Municipal agriculture office, while UA in this area is allowed farmers have no documentation to substantiate their tenure or legal rights. This indicates that even in the wards were UA is allowed in Kinondoni Municipality still, the security of tenure is low. Lack of security of tenure has been evident in Mbweni Mpiji were areas which were said to be set aside for UA are now used as dumping site. The leaders, however, noted that this is a temporary matter and will be resolved within the near future.

In Bunju ward along Mpiji river, the government surveyed the whole area for the purpose of converting the land into residential uses. According to the WAO at Mabwepande in Bunju ward, *"there are large plots of land that are not developed within the ward, UA should continue in these undeveloped plots, UA activities that are conducted along Mpiji river are safe since farmers use fresh water from the river and are guided to protect the environment*". A recent discussion with a MALDO confirms that, the ministry of lands and human settlement developments has allocated plots for residential purposes within the land set aside for UA along Mpiji river.

CONCLUSIONS

Generally, local leaders are in support of UA in Kinondoni Municipality. However, discussion on the three criteria of governance has revealed a number of issues and challenges associated with UA in Kinondoni Municipality. Farmers have been left to fend for themselves. Lack of proper plans has pushed farmers to some in-appropriate solutions. This is not healthy for the development of UA. In order to ensure the sustainability of UA and solve the identified issues, there are various issues which are to be dealt with. First, the Kinondoni Municipal government should designate a sizable land for UA in various areas. This will create both income generating activities for low income earners and a source of food for all urban residents. This land should be secured and incorporated in the Municipal development plans. On the other side, the voiceless farmers ought to organise themselves in groups/associations which are powerful and push their agenda to Municipal official through their local leaders. One of the agenda is the identification of UA activities as a source of income that requires a formal recognition. While we have noted the scarcity of water/irrigation facilities, we are of the opinion that the credibility of UA depends on the farmers themselves. We thus urge the urban farmers should adhere to farming practices which ensure the protection of customers' safety by restraining from using intoxicated irrigation water. Farmers should also strive to protect the environment. Lastly, the government and other stakeholder should create enabling environment for marketing and storage of the produce to avoid waste and promote self-employment.

For example the local government can consider sensitizing farmers on the establishment of the farmers market on top of the normal local market. The study is of the opinion that the implementation of these ideas gathered from the local leaders can be beneficial to the urban farmers and the Kinondoni residents in general. It will also deal with dangers of unsafe vegetables that are currently flooding the market.

ABBREVIATIONS

UA- Urban Agriculture; **WAO**- Ward Agricultural Officer;

DCP- Dar Es Salaam City Profile; **WEO**- Ward Executive Officer; **WLO-** Ward Livestock Officer; **DADPs**- District Agricultural Development Programs, **MALDO**- Municipal Agricultural and Livestock Development Officer; **SCINAP**- Sustainable Cities International Network-Africa Programme.

Conflict of Interests

The author have not declared any conflict of interests.

REFERENCE

Bryld E (2003). 'Potentials, problems and Policy implications for Urban Agriculture in developing countries', Agric. Human Values 20:79-86.

Diallo S (1993). "A Plot of One's Own in West African Cities." Int. Dev. Res. Centre (Ottawa) Reports 21(3):8-9.

Dongus S, Nyika D, Khadija K, Mtasiwa D, MshindaH, Gosoniu L, Axel D, Marcel T, Gerry FK, Marcia CC (2009). "Urban Agriculture and Anopheles habitats in Dar Es Salaam, Tanzania", Geospatial Health 3(2):189-210.http://www.geospatialhealth.unina.it/articles/v3i2/gh-v3i2-06-dongus.pdf

Foeken D (2005). Urban Agriculture in East Africa as A Tool for Poverty Reduction: A Legal and Policy Dilemma? ASC Working Paper, Netherlands. http://www.ascleiden.nl/pdf/workingpaper65.pdf

Foeken D, Sofer M, Mlozi M (2004), Urban agriculture in Tanzania: Issues of sustainability. Leiden: African Studies Centre, Research Report 75.

Grindle (2010). Good Governance: The Inflation of an Idea. Working paper No. 202. October 2010. Centre for International Development at Harvard University. http://www.hks.harvard.edu/var/ezp_site/storage/fckeditor/file/pdfs/centers-programs/centers/cid/publications/faculty/wp/202.pdf

Jacobi P, Amend J, Kiango S (2000). Urban Agriculture in Dar es Salaam: Providing an Indispensable Part of the Diet. http://www.futurepolicy.org/fileadmin/user_upload/Axel/Urban_Farming/City_Case_Study_Dar_es_Salaam.pdf

Jreisat J (2002). Governance and Developing Countries.Brill. Germany.

Kaufmann D, Kraay A, Mastruzzi M (2010). The Worldwide Governance Indicators: Methodology and Analytical Issues. Policy Res. Working Paper 5430.World Bank. USA. http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1682130

Kjær A (2004). Governance.Wiley Blackwell. UK. http://books.google.com.ng/books/about/Governance.html?id=AY5SIsf1nI4C&redir_esc=y

Maxwell J (1998). Designing a Qualitative Study. In: L. Bickman, & D. Rog, Handbook of Applied Social Research Methods (pp. 69-100). Thousand Oak, CA: Sage Publishers.

Mkwela H, Banyani M (2008). Urban Farming: A Sustainable Solution to Reduce Solid Waste Problems in Dar es Salaam, Tanzania. RICS publication. UK

Mlambo A (2002). Institutionalizing urban agriculture in Dar es salaam city through the EPM process Proc. of the E-Conference on Appropriate Methods for Urban Agriculture. Research, Policy development, Planning, Implementation and Evaluation, RUAF: Netherlands, pp 1-10.

Mlozi M (1997). Impacts of urban agriculture in Dar es Salaam, Tanzania. The Environmentalist 17(2):115-124.

Mwalukasa M (1999). Institutional Aspects of Urban Agriculture in the City of Dar es Salaam, Tanzania.

Mwalukasa M (2000). Institutional aspects of urban agriculture in the city of Dar es Salaam.Thematic Paper 6 Institutional Aspects of Urban Agriculture. http://www.ruaf.org/sites/default/files/Theme6_1_1.PDF

Oliver P (2004). Writing Your Thesis. London: Sage Publications.

Pierre J, Peters BG (2000). Governance, Politics and the State.St.Martins Press.

Powel -Taylor E, Renner M (2003). Analyzing Qualitative Data. Retrieved from University of Wisconsin: http://www.learningstore.uwex.edu/pdf/G3658-12.pdf

Rakodi C (1988). "Urban Agriculture: Research Questions and Zambian Evidence." J. Modern Afr. Stud. 26(3):495-515.

Sawio C (1998). Cities Feeding People Initiatives-Managing Urban Agriculture in Dar es Salaam City.IDRC. Canada.

Schmidt S (2011). Urban agriculture in Dar es salaam, Tanzania. #7-12, Food Policy for Developing Counties: Case studies, ed. P. Pinstrup-Andersen., F. Cheng., Cornell University, pp 1-10.

Stewart P (2000). Strategic IT Maturity of Construction Companies. PhD Thesis. Melbourne, Australia: Department of Construction, Royal Melbourne University Institute of Technology.

Yeung, YM (1988). "Agricultural Land Use in Asia Cities." Land Use Policy 5(1):79-82.

Yin R (1984). Case Study Research-Design and Methods. London: Sage.

Yin R (2009). Case Study Research: Design and Methods. Sage Publications. Forth edition. USA.

Citation

The Town and Country Planning (Urban Farming) Regulations(1992) http://faolex.fao.org/cgi-bin/faolex.exe?rec_id=005242&database=FAOLEX&search_type=link&table=result&lang=eng&format_name=@ERALL

URT, Dar es Salaam City Profile, Document Prepared by Dar es Salaam City Council with advice from Cities and Health Programme, WHO Centre for Development, Kobe, Japan, November 2004.

academicJournals

Vol. 7(3), pp. 47-57, May, 2014
DOI: 10.5897/JGRP2013.0409
ISSN 2070-1845

http://www.academicjournals.org/JGRP

Journal of Geography and Regional Planning

Full Length Research Paper

A grid-based approach for refining population data in rural areas

Dulal Chandra Roy[1*] and Thomas Blaschke[2]

[1]Ministry of Planning, Government of Bangladesh, Sher-e-Bangla Nagar, Dhaka 1207, Bangladesh.
[2]Department of Geoinformatics - Z_GIS, University of Salzburg, Hellbrunnerstrasse 34, Salzburg 5020, Austria.

Received 21 August, 2013; Accepted 15 April, 2014

Accurate and up-to-date population data is a prerequisite for many different applications, including risk and vulnerability management. There is, however, a shortage of data with a high spatial resolution, particularly in developing countries. Population densities are determined either by population census, typically conducted every ten years, or from global grid-based (raster) population datasets with relatively low resolution. Global population datasets are designed for global modeling studies, including climate change research, and their resolution is generally too low for local or community purposes. This paper presents a methodology for transforming population census data into grid-based (raster) population data with a relatively high resolution (100 m). Population census data, land cover, rural settlement data, and other geospatial datasets were utilized for a study area in the Khulna district of Bangladesh. Local experts validated the geographic information system (GIS)-derived population dataset as realistic and reasonably accurate. Our derived gridded population data was compared with the available LandScan global dataset. The overall difference between the population for 2010, which was projected from the 2001 census data, and our gridded population data was about 2.4% whereas the LandScan data overestimated the population in the study area by 49%.

Key words: Population density, spatial interpolation, geographic information system, bangladesh, Land Scan.

INTRODUCTION

It is of great importance for many spatial decision-making processes to have data that is both accurate and up-to-date. Population data with an appropriate format and resolution is required for a variety of applications such as spatial planning processes, disaster and emergency management, and risk and vulnerability assessment (Aubrecht et al., 2010a; Hall et al., 2008; Schneiderbauer, 2007; Sweitzer and Langaas, 1995; Tatem and Linard, 2011). In many countries, particularly the developing countries, population censuses are carried out every ten years and the population data from the census is made available to the public in aggregated form as statistical yearbooks, usually divided into administrative areas or political units. However, as pointed out by Deichmann et al. (2001), cross-disciplinary studies require datasets that are referenced

*Corresponding author E-mail: dulalroy@yahoo.com

to a uniform coordinate system rather than to irregular administrative units, since the integration of such vector-based population data into spatial modelling is problematic. The availability of grid-based (raster) population data is therefore vital for the important tasks of spatial integration and analysis, for ease of computation, and for spatial modelling, for example (Schneiderbauer, 2007; Aubrecht et al., 2013). High-resolution gridded data is also particularly important for spatial vulnerability and risk assessment, especially at a local or community level (Kienberger, 2012; Rafiq and Blaschke, 2012; Roy and Blaschke, in press). Schneiderbauer (2007) highlighted that the lack of recent population data at a high spatial resolution hampers crisis management activities. High-resolution contemporary data on human population distributions are a prerequisite for accurate measurement of the impacts of population growth, for monitoring changes, and for planning infrastructure (Tatem et al., 2007; Linard et al., 2012; Gaughan et al., 2013).

In recent years various scientific communities around the world have undertaken a number of initiatives aiming to develop techniques and methodologies for transforming population vector data (based on census counts) into gridded (raster) data. The first global population density estimate in raster format was developed in response to requests from international agriculture research institutes (Deichmann, 1996). The center for international earth science information network (CIESIN) of Columbia university developed the “gridded population of the world (GPW)”, a large-scale data product that demonstrates the spatial distribution of population across the globe at a resolution of 2.5 arc-minutes, that is, 5 km (CIESIN, 2005). It was first developed at the national center for geographic information analysis (NCGIA) in 1995 (Tobler et al., 1997). The GPW database uses two basic inputs: non-spatial population estimates (that is, tables of population counts listed by area names) and spatially explicit administrative boundary data. A proportional allocation gridding algorithm (areal weighting scheme) utilizing more than 300,000 national and sub-national administrative units, is used to assign population values to grid cells.

Other initiatives have included the global rural-urban mapping project (GRUMP) population dataset developed by the CIESIN, which is available at a resolution of 30 arc-seconds (CIESIN, 2005). The data products include population count grids (raw counts), population density grids (per square km), land area grids (actual area, net of ice and water), mean geographic unit area grids, urban extent grids, centroids, a national identifier grid, national boundaries, coastlines and settlement points. The algorithm employed is based on the GPW approach described above and uses approximately one million national and sub-national geographic units.

In an another initiative, the LandScan datasets developed by the oak ridge national laboratory (ORNL) provide population density grids at a global level, with approximately 1 km resolution, through an interpolation method (LandScan, 2010). In this case the allocation of population is based on likelihood coefficients for slope categories, distances from major roads, populated places, night time lights, and land cover (Mirella et al., 2005).

In a number of industrialized countries, gridded population data suitable for use in a variety of applications is available from the relevant statistical agencies (Aubrecht et al., 2010b). Kienberger et al. (2009) used gridded population data for spatial modelling of socio-economic vulnerability in the Salzach River catchment area, Austria. Gallego et al. (2011) described methods to produce a dasymetric population density grid of the European Union at a 100 m resolution. Their main ancillary information source was the CORINE land cover database distributed by the European environment agency, and they also integrated information from the Eurostat point survey (land use and land cover frame survey) into the parameter estimation of some of the approaches tested. Hall et al. (2012) compare gridded population data products for parts of Sweden with high-resolution population records obtained from the Swedish national registry through their regional office in Scania, Sweden. They concluded that further research was required into the quality of gridded population data, through comparisons with reference data such as high-resolution population data.

In a recent study, Scholz et al. (2013) disaggregated 1 km population density grids created by the European forum for geostatistics to target resolutions of 100 and 500 m. The resulting population grids were evaluated with respect to both reference population datasets and a random population dataset. It is interesting to note that the results from Scholz et al. (2013) indicate that the disaggregated population grid with 500 m resolution is more accurate than that with 100 m resolution and has a lower correlation with the random population grid. This study therefore indicates that the highest spatial resolution is not necessary the most accurate.

Balk et al. (2006) described the basic methods for constructing estimates of global population distribution with attention to recent advances in improving both spatial and temporal resolution. To evaluate the optimal resolution for the study of disease, they discussed the native resolution of the data inputs as well as that of the resulting outputs. Elvidge et al. (2009) produced a global poverty map at 30 arc-sec resolution (approximately 1 km) using a poverty index calculated by dividing population count by the brightness of satellite observed lighting. In July, 2011 the Asiapop project was initiated with the aim of producing population distribution maps for the whole of Asia (Asiapop, 2013). This dataset was not available in time for our study, but the Asiapop project (together with other attempts to provide continuous raster datasets) reflects the high level of demand for such data.

From studying the literature we observe that

methodologies for the development of grid-based population data are not readily available despite being urgently required in developing countries for crucial purposes such as emergency and crisis management, risk assessment, etc. Many developing countries such as Bangladesh have very high population densities. Apart from the urban areas, population densities are also high in the coastal and rural areas of these countries (Rabbani, 2009). These coastal and rural populations are often at great risk to the adverse effects of climate change and frequent natural disasters such as floods, cyclones, etc. (Mondal and Tatem, 2012). Grid-based population datasets with higher resolutions are therefore urgently needed for risk and vulnerability assessment in these areas (Kienberger, 2012; Rafiq and Blaschke, 2012; Roy and Blaschke, in press).

In this paper we hypothesize that census-based rural population data can be transformed into gridded data using various datasets and techniques at a relatively high resolution. At first, we outline the methodology for transforming census-based rural population data into gridded data at a relatively high resolution (100 m). Rural settlement data, population census data, and other geospatial datasets were collected from the relevant local authorities in Bangladesh; the methodologies and GIS techniques used for the transformation of population census data into gridded population data are described below. Finally, the resulting gridded population data is compared with the available LandScan global datasets, and validation techniques are used to evaluate the results of our transformation.

The approach developed in this study has a number of distinctive features. Firstly, it presents a grid-based methodology for developing gridded population data especially in the context of developing countries. This approach surmounts the problems of data availability especially in developing countries as higher resolution gridded population data is not readily available despite being urgently required for various crucial purposes. As described earlier, the spatial resolution for most of the existing gridded global population datasets is relatively coarse. As a result, they can be used at a continental level and sometimes at a national level, but are not suitable for use at local or community levels; such use would require population density datasets with higher resolutions. Therefore, the current approach focuses on developing gridded population data at higher resolution at the local or community level.

Study area

Bangladesh is bordered by India to the west, north, and northeast, by Myanmar to the southeast, and by the Bay of Bengal to the south. It lies between 20°34' and 26°38'N, and between 88°01' and 92°41' E. Bangladesh is located in the delta formed by three major rivers, the Ganges, the Brahmaputra, and the Meghna (the GBM), which is one of the largest deltas in the world. The combined basins of the GMB, together with their tributaries and distributaries, cover approximately 1.7 million km^2 in Bangladesh, Bhutan, India, Nepal and Tibetan China; only 7.5% of the combined catchment areas lie within Bangladesh. The country is mostly flat except for some areas in the northeast and southeast, with about 50% of the land lying less than 7 meters above the mean sea level (MoDMR, 2008).

The country has an area of 147,570 km^2, divided into 7 administrative divisions and 64 districts. The selected study area is the Dacope upazila (sub-district) of the Khulna District, which is located in the south-western coastal region of Bangladesh (Figure 1). It lies between 22°24' and 22°40' N, and between 89°24' and 89°35' E. The upazila occupies a total area of 991.57 km^2, comprising 706 km^2 (71%) in the Sundarbans reserve forest and 285.57 km^2 (29%) in non-forest areas (BBS, 2001). The 2001 national population census, which was the latest source of population information available during this study, indicated a total population for the Dacope upazila of 157,489. Using an annual growth rate of 1.4% the Upazila's population (excluding forest areas) is projected to have increased to 176,054 in 2010. This gives a population density for the total area of the Upazila in 2010 (including the forest areas) of 183 per km^2. If the forest areas are excluded, the population density for the study area increases to 616 per km^2.

The Upazila is divided into 10 unions (the lowest administrative units in the Bangladesh government system) and 26 mauzas (spatial units with one or more settlements). The southern border of the Upazila lies in protected forests that extend to the bay of bengal coastline. The study area is frequently damaged by floods and erosion due to a high density of rivers and canals: road infrastructure in the upazila is therefore not in good condition. According to the 2001 population census, the predominant form of housing in the Upazila is the ‘kutcha’ (89.81%), which is characterized by housing materials such as mud, thatch and bamboo (BBS, 2001). These ‘kutcha’ structures are very susceptible to natural hazards such as floods, cyclones, storm surges, etc.

METHODOLOGY - TRANSFORMATION Of CENSUS POPULATION DATA INTO GRIDDED DATA

Data collection

Up to date, accessible and reliable dataset are essential for transformation of census population data into gridded data. The collection of geospatial and ancillary data is a key step in the present study. Different datasets were collected for transformation into gridded data, including population census data, transportation and infrastructure datasets and data from satellite imagery. Population census data and other socio-economic data were obtained from the Bangladesh bureau of statistics (BBS). A census is conducted approximately every ten years in Bangladesh and, as stated previously, and the 2001 national population census was the latest source of information available at the time of our data

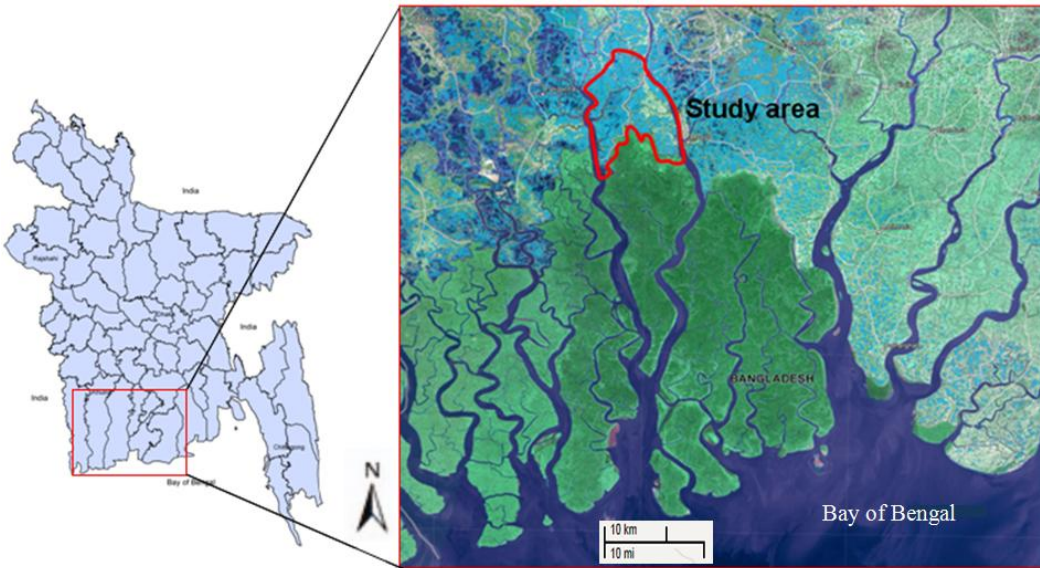

Figure 1. Location of the study area in the context of Bangladesh and its coastal areas

acquisition in 2010. The GIS datasets for the study area (which included various administrative boundaries, rivers, roads, embankments, settlements, educational institutions, health centres, shelters, markets, etc.) were obtained from the GIS unit of the local government engineering department.

Additional satellite images such as Landsat 7 ETM+, ASTER (advanced spaceborne thermal emission and reflection radiometer), and IRS (Indian remote sensing) images, were also acquired. The LandScan gridded population dataset was also obtained from the oak ridge national laboratory website (http://www.ornl.gov/sci/landscan). The contents of all the datasets collected in this study were checked for plausibility and topicality. Some of the GIS data layers such as settlements, roads, embankments, etc. were not considered to be sufficiently up-to-date or accurate for inclusion as changes that had occurred over time to these physical features within the study area were not reflected in the datasets.

In such instances, the relevant datasets were updated and modified with the help of available satellite imagery for the study area. These included Landsat 7 ETM+, ASTER, and IRS images from April, 2009, November, 2008 and February, 2007 respectively. Figure 2 shows the census-based population density for the different mauzas within the study area (a), and a snapshot of the updated settlement data using the ASTER (15 m) satellite image (b).

GIS-based interpolation

As mentioned previously, our objective was to derive grid-based population data suitable for use in a variety of applications. As discussed in section 1, the spatial resolution of most gridded global population datasets is relatively coarse (example, approximately 1 km for the LandScan dataset). The recently developed AsiaPop dataset provides gridded population data at 100 m resolution but was not available at the time of data acquisition for this study. We have developed a methodology to transform the census population data into gridded population data (100 m). For this purpose two assumptions were made when considering population density, settlement patterns, expert consultations, and other characteristics of the study area: firstly, that people only live within the outlines of rural settlements, and secondly, that they are evenly distributed within these areas. We consulted a number of experts regarding their valuable opinions and experiences regarding the assumptions made in this study and other relevant aspects of population data in Bangladesh. The details about the selection of experts are provided in section 4.2. The experts' consultations indicate that the population are uniformly distributed over the settlements as the study area is predominantly rural in characteristics. The methodology of transforming the census population data into gridded population data was divided into a number of consecutive steps.

In the preliminary stage of our work, rural settlement data was carefully checked against the census data for each mauza. It was observed that rural settlement data was not separated for a particular mauza. The settlement data was only available for the whole study area. Thus, the spatial distribution of rural settlements was checked against the boundaries of each mauza. The spatial distribution of rural settlements within the mauzas showed that the boundaries of some settlements overlapped with more than one mauza. Therefore, the settlements that overlapped mauza boundaries were divided between the relevant mauzas in order to distribute population over the settlements in a particular mauza. For that purpose, the settlements that overlapped mauza boundaries were differentiated by overlaying the 'mauza' polygons on the 'settlement' polygons (Figure 3). Afterwards, the areas of individual settlements and the total area of all settlements in a particular mauza were calculated as a basis for estimating settlement populations. The proportion of the population in an individual settlement that was allocated to a particular mauza was calculated using the following equation:

$$P_{ij} = \frac{P_i \times S_{ij}}{\sum S_{ij}} \quad (1)$$

where P_{ij} = Population of settlement j in Mauza i
P_i = Total Population of Mauza i
S_{ij} = Area of settlement j in Mauza i

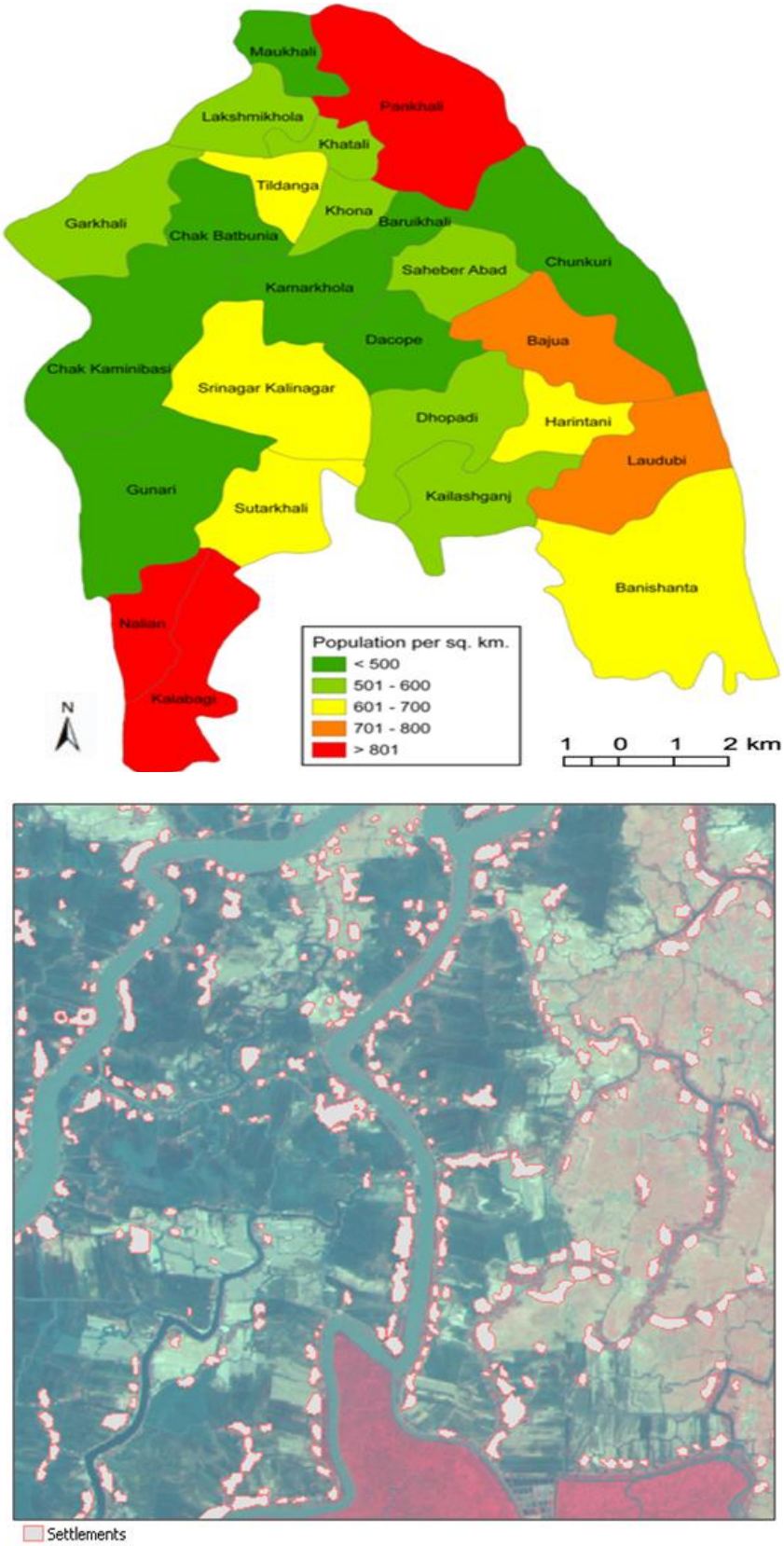

Figure 2. Census-based population density for the different mauzas within the study area (a), and settlement data updated from ASTER (15 m) satellite image (b)

Figure 3. Settlements of a particular mauza differentiated by overlaying 'mauza' polygons and 'settlement' polygons

$\sum S_{ij}$ = Sum of areas of all settlements in Mauza *i*

For this calculation the total population of mauza *i (Pi)* was available from the population census data. The area of an individual settlement *j* within mauza *i (Sij)* and the sum of areas of all settlements within mauza *i (□ Sij)*were calculated in ArcGIS.

Now the population of an individual settlement in a particular mauza is available. Our ultimate aim is to obtain population figures for grids with a size of 100 m. With a view to achieving this target, a polygon vector grid layer with a grid size of 100 m was created. The vector grid layer and the settlement layer with the population counts were then overlaid, in order to identify the intersected settlements (Figure 4). Here, the intersected settlements were created after intersecting settlement polygons with vector grid layer. The areas of the individual intersected settlements were then calculated and their respective population numbers estimated from these areas. The proportion of the population living in the intersected settlements under the respective grid cells was calculated using the following equation:

$$T_{km} = \frac{P_{ij} \times A_{km}}{S_{ij}} \quad (2)$$

Where T_{km} = Population of intersected settlement *m* within grid cell *k*

A_{km} = Area of intersected settlement *m* within grid cell *k*

P_{ij} = Population of settlement *j* in Mauza *i*

S_{ij} = Area of settlement *j* in Mauza *i*

Following this calculation, each intersected settlement within a 100x100 m cell was assigned the corresponding population. After estimating the settlement populations the intersected settlements, which have individual population counts, were converted into the 100x100 m raster grid. Each cell then contained the relevant population number. Figure 5 shows the conversion process from the intersected settlements into the population grid (100x100 m).

RESULTS

Population maps and comparison

A comparison was made between the census population data and the developed gridded data in order to check the accuracy of the results. Little difference can be observed between the census population data and the population calculated from our own gridded data. The total population of the study area for 2010, as projected from the 2001 census population, was 176,054 while the total population from all grid cells in the studied area was 171,883, a difference of 4,171 or about 2.37%. The main reason for this difference is the rounding up or down of the population figures at the end of the calculation process. After the transformation process in the study, some settlements received fractional population numbers

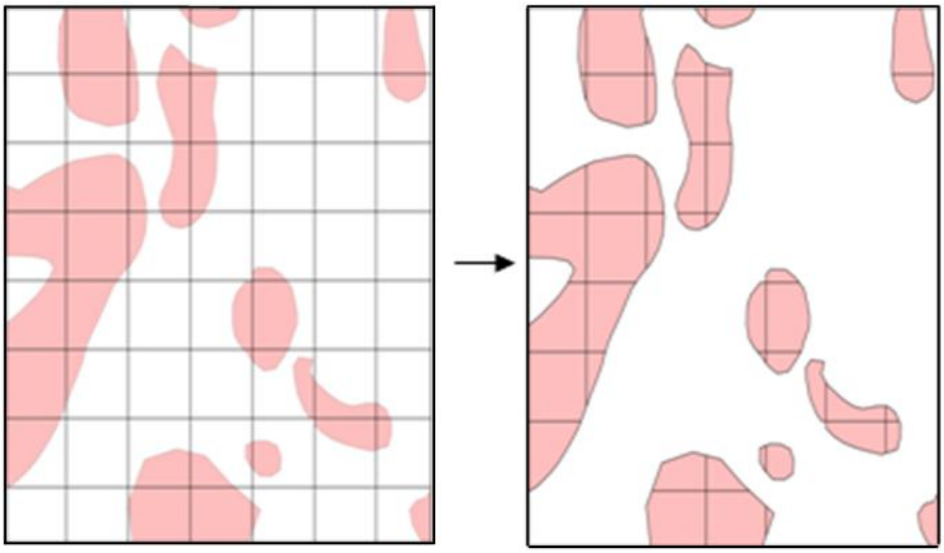

Figure 4. Intersected settlements created after intersection of settlement layer with 100 m vector grid data layer

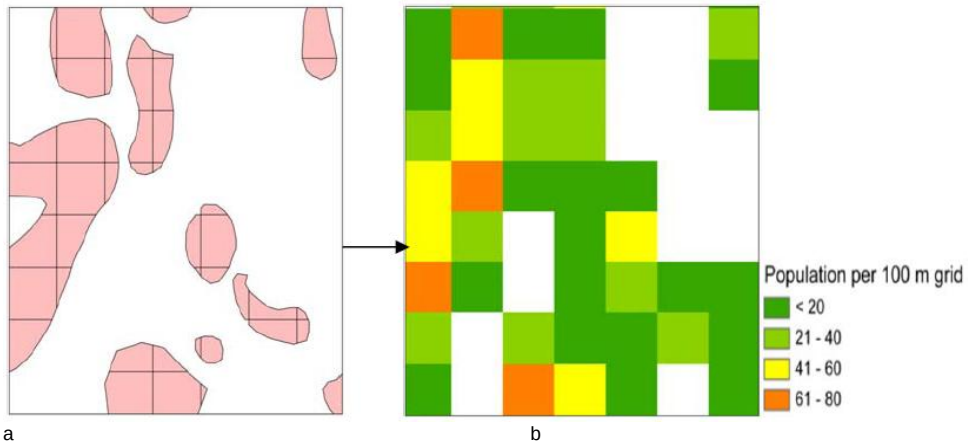

Figure 5. Intersected settlement areas converted into raster population grids (100 m)

which were rounded up or down to integer values.

In order to evaluate the quality of our derived gridded population dataset it was compared with the LandScan gridded dataset, was obtained from the oak ridge national laboratory (ORNL) website and has a resolution of approximately 1 km. This population data model uses sub-national level census counts for each country and primary geospatial and ancillary datasets (LandScan, 2010). For an effective comparison, the same spatial resolution (approximately 1x1 km grid size) was used for both of the gridded population datasets. For this purpose, our 100x100 m population grid was aggregated into a 1 km grid using spatial aggregation techniques in ArcGIS. Figure 6 shows a comparison between our own gridded population data and that from LandScan.

The visual comparison reveals a greater variation in population density within our data than in the LandScan data, which consequently appears smoother. This seems plausible for a worldwide dataset that is based on statistical correlations between population, land cover, distance to roads, etc. (see Section 1). Examination of the LandScan data reveals a total population estimate for the studied area of 262,487, which is 86,433 or about 49% higher than the figure projected from the 2001 census population. As mentioned previously, the total population in our gridded data is 171,883, which is approximately 2.37% (4,171) less than the census population, which appears to indicate that our results from the spatial disaggregation of the population are more realistic, and accurate to within less than 3%.

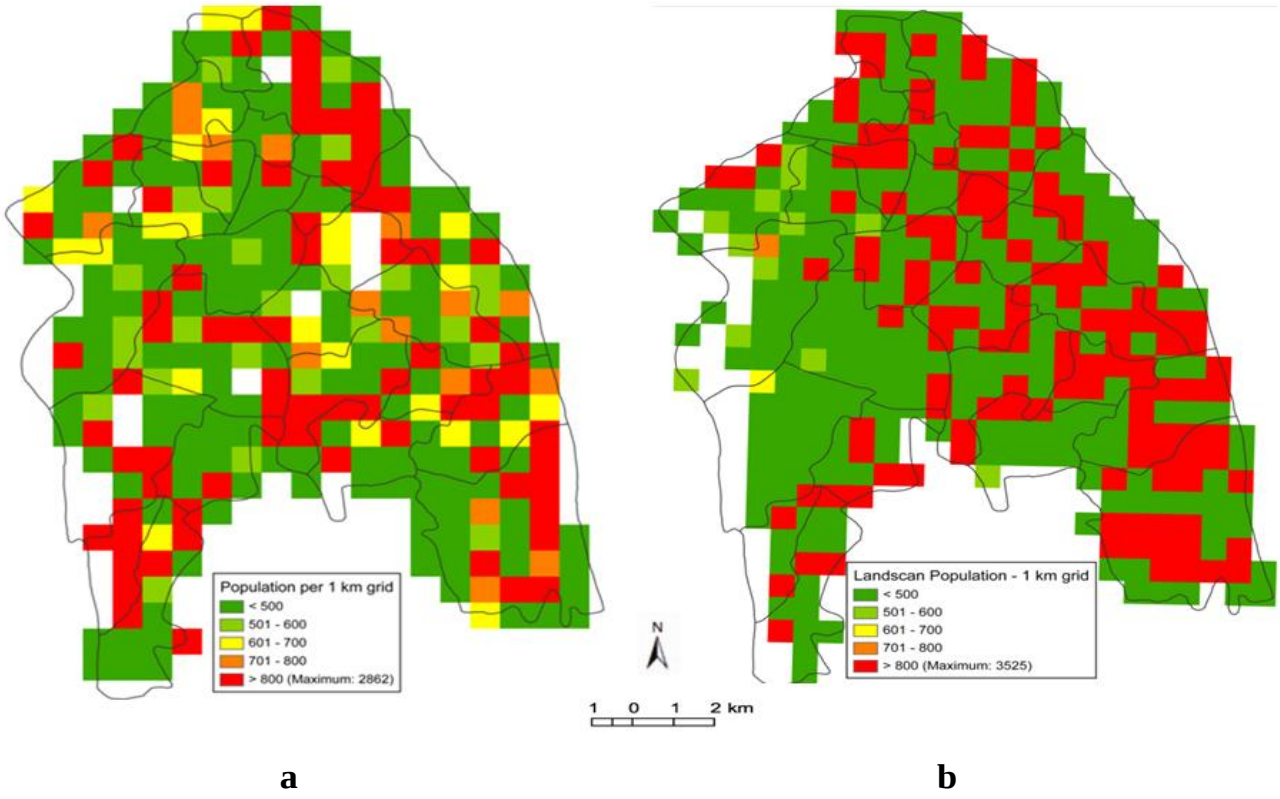

Figure 6. Visual comparison between our own gridded population data (a) and that from LandScan (b)

Validation

The accuracy of the gridded population data was checked by both quantitative and qualitative validations. Two qualitative validations were performed following the quantitative comparison described in the previous section. Firstly, our gridded population data was compared with the settlement population data calculated in section 3.2 using the 2001 census data. Figure 7 shows a rural settlement and population grids (100 m) converted from the settlement using GIS techniques. As expected due to the algorithm used, the total population from all grids within a settlement was equal to the total population of that particular settlement.

Secondly, our gridded population data was evaluated by 10 experts having a great deal of experience in the field of disaster management and emergency responses especially in the coastal areas of Bangladesh. The disaster experts were selected from various organizations such as government, non-government, local disaster management committees, voluntary, academic, and research institutions. During the field study, a standardized questionnaire survey was filled out by the disaster experts. This questionnaire survey was conducted with the objectives of obtaining their valuable opinions and suggestions from their past experiences in this field. For this purpose, a structured questionnaire was developed. Firstly, they were briefed about the background, the objectives, and the major components of the study. Secondly, they were asked to provide any relevant population data and information on the study area and were also invited to share their valuable opinions and experiences regarding the availability and accuracy of population data, the requirement for gridded data, and other relevant aspects of population data in Bangladesh. Finally, they were asked to investigate and assess the results, and in particular to comment on the accuracy of the derived results and to raise any important observations.

Based on these validations and the opinions of the local experts, our methodology for gridding rural population data shows promising and realistic results. One particular observation made by the local experts was that the areas that are highly populated are also assessed as highly populated in our gridded data. This observation is important in the context of vulnerability since it means we can assume that the vast majority of population hot spots are well represented.

Implications of the increased accuracy

The increased accuracy of gridded population data will impact disaster management, vulnerability assessment,

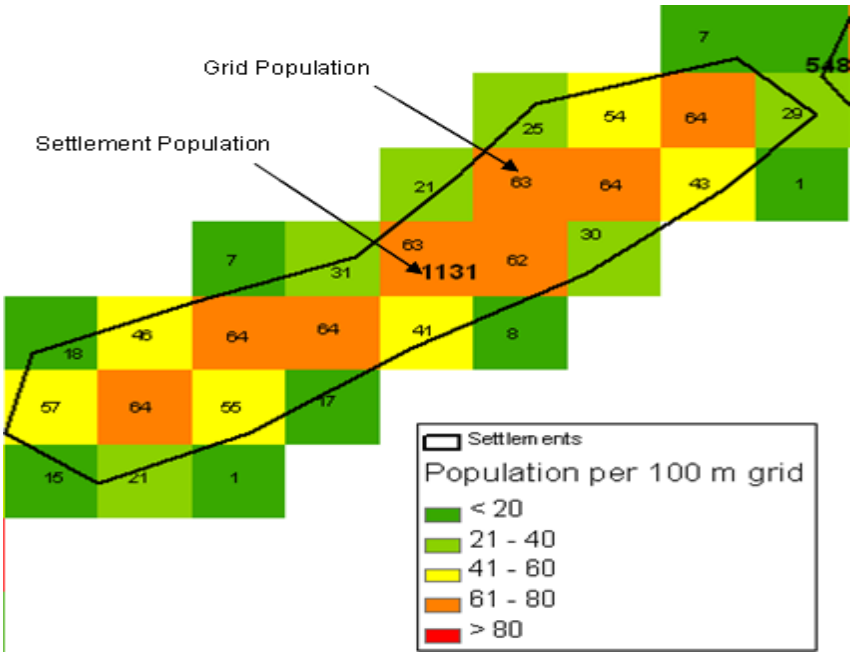

Figure 7. A rural settlement and population grids (100 m) converted from the settlement

emergency response, poverty management, and other crucial activities. The gridded data can play a great role in the area of risk and vulnerability assessment especially in flood-prone and developing countries like Bangladesh. In most of the countries, population densities are very high. The coastal and rural populations are often at great risk to the adverse effects of climate change and frequent natural disasters. It can be very useful to estimate the number of people at risk due to floods and other natural disasters in a particular region. The availability of gridded population data at higher resolution can be very effective in monitoring extreme events, rescue and evacuation operations, rehabilitation programs, etc. In developing countries, the increased accuracy of gridded population data can facilitate poverty analysis, poverty management, disease control, health care management, and other critical operations.

CONCLUSIONS

We have developed a grid-based methodology for calculating rural population density at relatively high resolution, which the authors consider to be applicable at a local level. The methodology uses census population data, rural settlement data, and other geospatial datasets for making grid-based estimates of rural population density which we have applied to a sub-district in Bangladesh.

The resulting datasets are shown to be far more accurate than the available LandScan global datasets. This is not simply because of the higher spatial resolution in our gridded dataset, since our results remain much closer to the population figures from the census data when the same spatial resolution is used for both datasets. We believe that the approach that we have presented herein provides a useful method for researchers or institutions to carry out geographical analyses linking population with land use and geographical features. Demand for this type of analysis is likely to increase in the future. Spatial databases of human population are particularly important in disease burden estimation and epidemic modelling, as well as in resource allocation, disaster management, accessibility modelling, transport and city planning, poverty mapping, and environmental impact assessment, etc. (AsiaPop, 2013; Linard et al., 2010). High-income countries often have extensive mapping resources and expertise at their disposal with which to create such databases. There is, however, either a complete lack of appropriate gridded population data for low-income regions of the world, or the data that is available is of poor quality. The scarcity of mapping resources, lack of reliable validation data, and difficulties in obtaining high-resolution contemporary census statistics, remain major obstacles to settlement and population mapping across the low income regions of the world.

Our methodology demonstrates several distinct advantages over other existing methodologies for calculating gridded population densities, yielding reasonably accurate results in terms of population counts and providing relatively high-resolution (100 m) gridded population data. However, the overall performance of our approach depends largely on the quality of the input data, in particular

the rural settlement data and census population data. This data therefore needs to be accurate and up-to-date in order to develop qualitative and reliable gridded population data.

We anticipate that the methodology we have presented herein will be further improved in the future and can also be adapted to other appropriate contexts. More accurate and up-to-date rural settlement data will be required in order to develop high-accuracy population datasets in gridded (raster) format. The authors, feel that a number of potential areas exist for future research with regard to the development of high-resolution gridded population data. Firstly, further research is required into the development of gridded population datasets with higher resolutions, especially in the context of developing countries. Secondly, gridded datasets for other socio-economic indicators such as poverty, employment, health, water, and sanitation may be developed for effective application in, for example, spatial risk and vulnerability assessment, emergency management, e.t.c. Thirdly, the development and application of proper validation methodologies is important for effective evaluation of the resulting gridded population datasets. The authors stress that further validations will be required in order to improve existing methodologies.

ACKNOWLEDGEMENTS

We would like to thank the Austrian development co-operation (ADC) and the Austrian partnership programme in higher education and research for development (APPEAR) of the Austrian agency for international co-operation in education and research (OeAD) for providing financial grants for this research, as well as the Austrian science fund (FWF), for funding provided through the doctoral college GIScience (DK W 1237-N23). Additionally, we highly appreciate the comments and suggestions made by the anonymous reviewers.

Conflict of Interests

The authors have not declared any conflict of interests.

REFERENCES

Aubrecht C, Levy M, De Sherbinin A, Yetman G, Jaite M, Steinnocher K, Metzler S (2010a). Refinement of regionally modeled coastal zone population data enabling more accurate vulnerability and exposure assessments. Proceedings of International Disaster and Risk Conference IDRC 2010, Davos, Switzerland. http://www.slideshare.net/GRFDavos/refinement-of-regionally-modeled-coastal-zone-population-data-enabling-more-accurate-vulnerability-and-exposure-assessments

Aubrecht C, Yetman G, Balk D, Steinnocher K (2010b). What is to be expected from broad-scale population data? Showcase accessibility model validation using high-resolution census information. Proceedings of the 13th AGILE International Conference on Geographic Information Science, 2010, Guimaraes, Portugal. http://www.agile-online.org/Conference_Paper/CDs/agile_2010/ShortPapers_PDF/92_DOC.pdf

Aubrecht C, Özceylan D, Steinnocher K, Freire S (2013). Multi-level geospatial modeling of human exposure patterns and vulnerability indicators. Natural Hazards 68(1):147–163. http://link.springer.com/article/10.1007%2Fs11069-012-0389-9

Balk DL, Deichmann U, Yetman G, Pozzi F, Hay SI, Nelson A (2006). Determining Global Population Distribution: Methods, Applications and Data. Adv. Parasitol. 62:119-156. http://dx.doi.org/10.1016/S0065-308X(05)62004-0

BBS (2001). Bangladesh National Population Census 2001. Bangladesh Bureau of Statistics (BBS), Statistics and Informatics Division, Ministry of Planning, Government of Bangladesh, Dhaka. http://www.bbs.gov.bd/PageSearchContent.aspx?key=Statistics%20and%20Informatics%20Division,%20Ministry%20of%20Planning,%20Government%20of%20Bangladesh,%20Dhaka

CIESIN (Center for International Earth Science Information Network) (2005). Gridded population of the world (GPW). V3 [online], New York, Columbia University, USA. http://sedac.ciesin.columbia.edu/data/set/gpw-v3-centroids

Deichmann U (1996). A review of spatial population database design and modeling. Technical Report 96-3, National Center for Geographic Information and Analysis, Santa Barbara, USA. http://www.amazon.com/spatial-population-database-modeling-Technical/dp/B0006QNF7I

Deichmann U, Balk D, Yetman G (2001). Transforming population data for interdisciplinary usages: from census to grid. http://sedac.ciesin.columbia.edu/gpw-v2/GPWdocumentation.pdf

Elvidge CD, Sutton PC, Ghosh T, Tuttle BT, Baugh KE, Bhaduri B, Bright E (2009). A global poverty map derived from satellite data. Comput. Geosci. 35(8):1652-1660. http://dx.doi.org/10.1016/j.cageo.2009.01.009

Gaughan AE, Stevens FR, Linard C, Jia P, Tatem AJ (2013). High resolution population distribution maps for Southeast Asia in 2010 and 2015. PLoS ONE 8(2):e55882.

Gallego FJ, Batista F, Rocha C, Mubareka S (2011). Disaggregating population density of the European Union with CORINE land cover. Int. J. Geogr. Inform. Sci. 25(12):2051-2069.

Hall O, Duit A, Caballero L (2008). World poverty, environmental vulnerability and population at risk for natural hazards. J. Maps 151-160.

Hall O, Stroh E, Paya F (2012). From census to grids: comparing gridded population of the world with Swedish census records. The Open Geogr J. 5:1-5.

Kienberger S (2012). Spatial modelling of social and economic vulnerability to floods at the district level in Buzi, Mozambique. Natural Hazards 64(3):2011-2019.

Kienberger S, Lang S, Zeil P (2009). Spatial vulnerability units - experts based spatial modeling of socio-economic vulnerability in the Salzach catchment, Austria. Natural Hazards and Earth System Sciences, 9:767-778.

Land Scan (2010). Land Scan documentation. Oak Ridge National Laboratory (ORNL), USA, http://www.ornl.gov/sci/landscan/landscan_documentation.shtml.

Linard C, Gilbert M, Tatem AJ (2010). Assessing the use of global land cover data for guiding large area population distribution modeling. Geojournal, **76**(5):525-538.

Linard C, Gilbert M, Snow RW, Noor AM, Tatem AJ (2012). Population distribution, settlement patterns and accessibility across Africa in 2010. PLoS ONE **7**(2):e31743.

Mirella S, Pozzi F, Ataman E, Huddlestone B, Bloise M (2005). Mapping global urban and rural population distributions. Environment and Natural Resources Series, 24, FAO, Rome.

MoDMR (Ministry of Disaster Management and Relief) (2008). National Plan for Disaster Management 2008-2015. Ministry of Disaster Management and Relief, Dhaka, Bangladesh.

Mondal P, Tatem AJ (2012). Uncertainties in measuring populations potentially impacted by sea level rise and coastal flooding. PLoS ONE **7**(10):e48191.

Rafiq L, Blaschke T (2012). Disaster risk and vulnerability in Pakistan at a district level. Geomatics, Natural Hazards Risk 3(4):324-341.

Roy DC, Blaschke T (in press). Spatial vulnerability assessment of floods in the coastal regions of Bangladesh. Geomatics, Natural Hazards and Risk. http://dx.doi.org/10.1080/19475705.2013.816785

Schneiderbauer S (2007). Risk and vulnerability to natural disasters – from broad view to focused perspective: theoretical background and applied methods for the identification of the most endangered populations in two case studies at different scales. PhD Dissertation, Free University of Berlin, Germany. http://edocs.fu-berlin.de/diss/servlets/MCRFileNodeServlet/FUDISS_derivate_00000 0003126/00_Schneiderbauer.pdf?hosts=

Scholz J, Andorfer M, Mittlböck M (2013). Spatial Accuracy Evaluation of Population Density Grid Disaggregations with Corine Land cover. Geographic Information Science at the Heart of Europe, Berlin, Heidelberg: Springer pp.267-283. http://link.springer.com/chapter/10.1007%2F978-3-319-00615-4_15

Sweitzer J, Langaas S (1995). Modelling population density in the Baltic Sea states using the digital chart of the world and other small scale datasets. In: Gudelis V, Povilanskas R, Roepstorff A (eds) Coastal conservation and management in the Baltic region: Proceedings of the EUCC-WWF conference, 2-8 May 1994, Riga-Klaipeda-Kaliningrad, pp.257-267.

Tatem AJ, Linard C (2011). Population mapping of poor countries. Nature 474:36.

Tatem AJ, Noor AM, Hagen CV, Gregorio AD, Hay SI (2007). High resolution population maps for low income nations: combining land cover and census in East Africa. PLoS ONE 2007(2):e1298.

Tobler W, Deichmann U, Gottsegen J, Maloy K (1997). World population in a grid of spherical quadrilaterals. Int. J. Popul.Geogr. 3:203-225.

Citations

AsiaPop (2013). AsiaPop. http://www.clas.ufl.edu/users/atatem/index_files/AsiaPop.htm.

Rabbani MG (2009). Climate forced migration: A massive threat to coastal people in Bangladesh. Clime Asia: Climate Action Network-South Asia newsletter, BCAS, Dhaka.

Journal of Geography and Regional Planning

Related Journals Published by Academic Journals

- Journal of Economics and International Finance
- Journal of Hospitality Management and Tourism
- International Journal of Sociology and Anthropology
- Journal of Public Administration and Policy Research
- African Journal of Marketing Management

academicJournals