The Portal component, strategic perspectives and review of tactical plans for full implementation of WUDAPT

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1. Introduction

Immense challenges on a global scale posed by climate changes, population growth and the concomitant increases in rates of urbanization require concerted societal attention and response. Computer models that simulate climate, weather and air quality provide important capabilities and tools for projecting and assessing risks posed by these challenges and for devising various coping strategies to mitigate projected impacts. As atmospheric models at global/macro-, meso- and micro-scales improve, they have greater needs for more detailed information on landscape characteristics, and their variation over space and time. This is particularly true of urbanised landscapes, which are dynamic, exhibit great spatial heterogeneity and exert considerable influence on climates at city, regional and global scales. Currently available urban data sets vary widely in (a) content, spatial coverage, level of detail, scale, features, and characteristics, (b) their type and sources of inputs, and even (c) degree of availability and accessibility. Conceptually what is needed is a global database that contains consistent information on cities at a detail suitable and readily accessible for a wide range of applications and for different types of models and analyses. WUDAPT (World Urban Database and Access Portal Tools) is a project to facilitate the development and utilization of advanced science-based modeling tools to collect globally distributed urban information for a myriad of model applications requiring specialized data on urban form and human activity (see Ching et al., 2014, Mills et al., 2015, and www.wudapt.org). Recognizing that the science in models is rapidly advancing and embodied with increasing sophistication, WUDAPT provides an innovative and adaptable data collection approach for requisite urban morphology and activity data in the short term and for future needs. Moreover, the Portal and its suite of tools are being designed to provide stakeholder communities with user friendly targeted capabilities to facilitate a host of urban applications. This presentation will describe current and future plans and objectives of the WUDAPT Portal and provide some example applications. Subsequently, we review and summarize the overall progress, outline detailed plans, describe our website, list opportunities for community involvement and country coordination, and suggest next steps towards achieving the goal of a fully implemented WUDAPT.

2. Project status:

WUDAPT is an initiative of the IAUC (Ching, 2012) proposed at its ICUC8 in 2013. Conceptually, it is a community based system (Fig 1) to create robust content for scientifically defensible modelling outcomes that are feasible and readily achievable with current technology, which will be publically available and accessible in a relatively short time frame, and is utilitarian with current, planned and potential capabilities for multiple urban modelling systems. Initial developments focussed on exploratory methodology and now on implementing an initial Level "0" database based on Local Climate Zone (Stewart and Oke 2013). A protocol and workflow for generating LCZ was developed and tested at a workshop in Dublin, Ireland in July 2013 (Bechtel, 2015a, 2015b) and is summarized in http://www.wudapt.org. Fig 2 illustrates examples of LCZ atlases for several

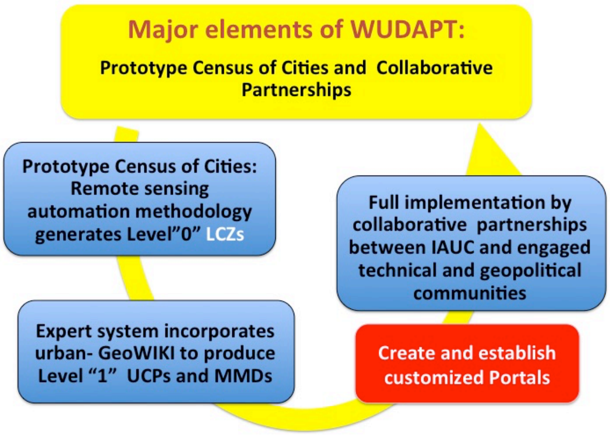

Fig 1: Conceptual framework of the WUDAPT

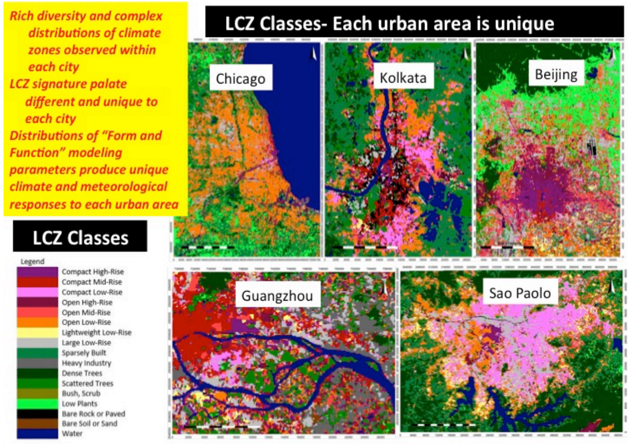

Fig 2: Examples of WUDAPT Level "0" generated at 2014 Workshop in Dublin Ireland

of the 16 cities created and derived at that workshop. Tables of urban parameters associated with each LCZ provide climate and weather models with inputs required for urban climate and mesoscale weather applications. Clearly, it is notable that each city had a unique distribution and pattern characteristics, or "DNA" of LCZs (Neophytou, 2015). In summary, the Dublin Workshop demonstrated that with relative ease, each participant was successful in generating the LCZ map for their selected city after a short training period, employing readily available source information (e.g., Landsat data) and knowledge of their cities. The impact of the success at the Workshop demonstrated the prospect of fully implementing WUDAPT globally at Level "0" is feasible. Already, it is highly encouraging that WRF — a mesoscale model (Fig.3) — is being run for Madrid, a large metropolitan area in Spain, using WUDAPT Level "0" in part to demonstrate the utility of the Table look-up parameter values for each LCZ. Preliminary results applying Level "0" data using BEP and BEP-BEM options in WRF for Madrid show interesting simulation sensitivities to energy use for heating in different LCZ classes and WRF's reactions, depending on synoptic conditions and land use properties in a wintertime UHI study (Brousse, 2015). Utilization of WUDAPT-type data for climate modelling is also underway (Feddema et al., 2015). These initial applications and on-going developments are encouraging and demonstrate pathways to fulfilling the concepts shown in Fig 1. Plans for development of the methodology and protocols for generating and producing WUDAPT data at Levels "1" and "2" are also underway (See et al., 2015). The design concept for Levels "1" and "2" is to support increasingly finer grid sizes for more refined scale-dependent mesoscale environmental model applications and assessments, and for their rapidly advancing science-based urban parameterizations (e.g., Masson, 2000, Martilli et al., 2002, Kusaka et al., 2001, Baklanov, 2009, Jackson et al., 2010). Further, to support climate and mesoscale modelling and an understanding that model outcomes are grid size dependent, we envision the WUDAPT portal to provide tools such as the Multi-Resolution Analysis or MRA (Mouzourides et al., 2013, Neophytou et al., 2015) that can facilitate this requirement (Fig 4).

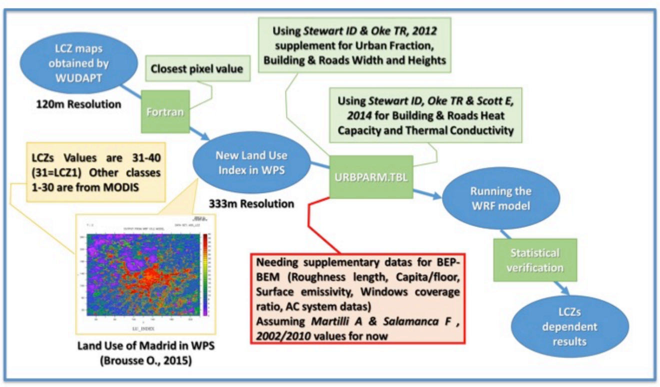

Fig. 3: Processing WUDAPT Level "0" data to running WRF –Urban, the case for Madrid, Spain

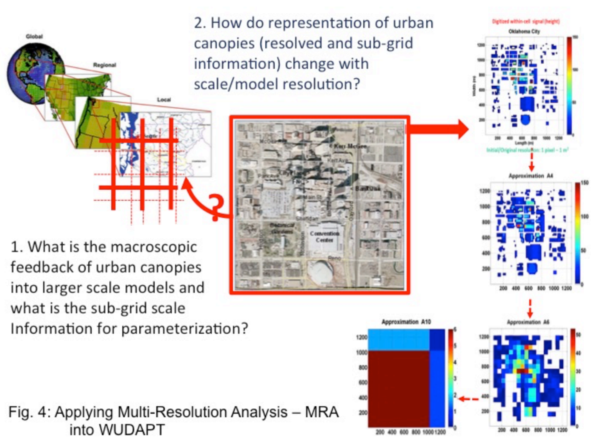

Fig. 4: Applying Multi-Resolution Analysis – MRA into WUDAPT

3. The WUDAPT Portal Developmental Concepts

Current environmental climate and mesoscale models require land use, form and function data in their respective grid systems. Their geographic domain, map projections, subdomain nested windows and gridding size are typically user-specified. Boundary and initial conditions are usually established as part of their overall system. Such modelling systems have various state of science treatments governing all major transport, energy exchange and chemical transformational processes, as well as vertical and horizontal exchange processes throughout the atmosphere (and water bodies) and between atmosphere and land and water surfaces for all grid cells. Finally, they must also have the means to treat sub-grid processes that are at scales finer than their finest grid sizes. Urban environments pose great modelling challenges to resolving processes at block and building scales, as well as their subgrid scale heterogeneities. By design, WUDAPT will provide a consistent set of data at city block size and for all the world's major cities and their adjacent surroundings.

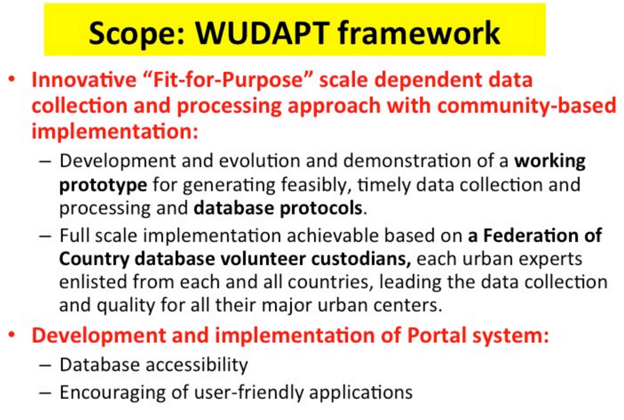

Fig. 5: Framework, objectives, and suggested implementation strategy for WUDAPT.

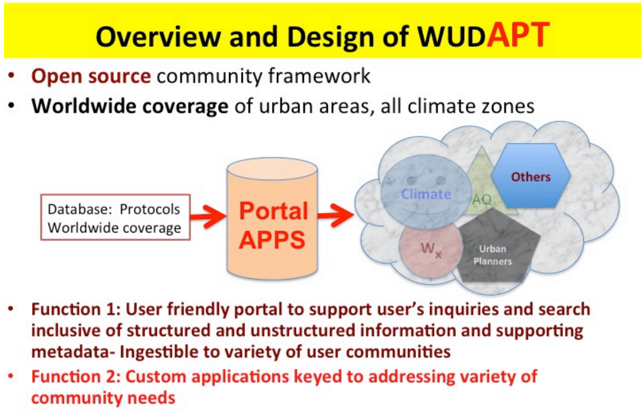

Fig. 6: Conceptual design functionalities of WUDAPT Portals and applications.

WUDAPT's data portal will serve two basic functionalities (Figs 5 and 6). First, it must satisfy the need for effective access to the on-going data collection at Level "0" and eventually the emerging Levels "1" and "2" database for all major cities around the world. The second function requires providing for the means to facilitate actionable utilization of this data. Currently, WUDAPT data servicing portal is "Geopedia" (Fig. 7) providing the means to ingest and make WUDAPT Level "0" information accessible. Methodologies for Levels "1" and "2" landcover, geometry, form and function data are currently being developed and tested using Geopedia to import on-line the GIS inputs from a customized Geo-wiki and crowdsourcing and, where available, Open Street Maps (See et al., 2015). As a part of the process, WUDAPT is responding to feedback from urban experts engaged in Level "0" data use to improve implementation of Level "1" and "2" methodologies (Fig 8). Currently, Level "1" and "2" data sampling have a minimum scale of120m to capture information at block scale. Metadata are collected to capture and characterize the 120m heterogeneities (e.g., building geometries and their wall/roof materials, landforms and vegetation coverage, and functions like heating and AC). This scale is a trade-off to optimally balance the practical need of full areal coverage for a region that is also capable of supporting a wide range of regional to fine grid modelling studies. Explicit data at an even finer scale would require additional resources, effort and sampling protocols; though such data could be a desirable future augmentation.

The second goal of the Portal is the development towards facilitating its capability to address the myriad of issues and applications expressed earlier; these include simple graphical displays, the grand challenges of population, climate changes, effective usage of limited water and energy resources, air pollution and greenhouse gas emissions, city-specific inquiries such as urban planning and managing risks from city specific UHI impacts under current and future climate conditions (Fig 9). As an initial step towards this objective, an effective functionality of the portal will be to facilitate basic applications such as the processing of data in terms of gridding, scaling and establishing model inputs to various modelling systems including meso-urban scale models such as WRF (Weather and Forecasting), TEB (Town Energy Budget), CLMU (Climate Model Urban). In this regard, incorporating the MRA tool (Fig 4) will facilitate handling their scale dependencies, empowering the processing of Levels "0," "1" and "2" data into specific model accepted formats, including map projection schemes and grid sizes (as an example for WRF modelling, WUDAPT data could be set up–rasterized–to provide the urban canopy parameters into the WPS, the pre-processing system for WRF system). This capability serves as an important step towards empowering broad usage of WUDAPT to perform requisite modelling needed for advanced applications.

An example of an application is a directly modelled fine grid (3km) heat stress advisory, such as those performed for Japanese cities (Kusaka et al., 2012), but using gridded UCPs from WUDAPT into WRF. A simpler example would be an extension of the type of study by Hanna et al. (2015) of climate change-induced heat waves enhancements from downscaled climate model projections and coarse grid (operational predictions) and the role that WUDAPT data at Level "0" to reflect urbanization on such guidance (Fig 10). For such types of applications, the current or new portal could be set up with a capability to either run climate simulations and/or meso regional to urban scale weather models for the relevant heat stress variables, as in Kusaka et al (2012) or as in Hanna et al (2015) to link (from offline) the outputs of regional scale models such as WRF for the required meteorological inputs needed to produce various heat stress indices conditioned with parameters from WUDAPTs LCZ to reflect urban classes.

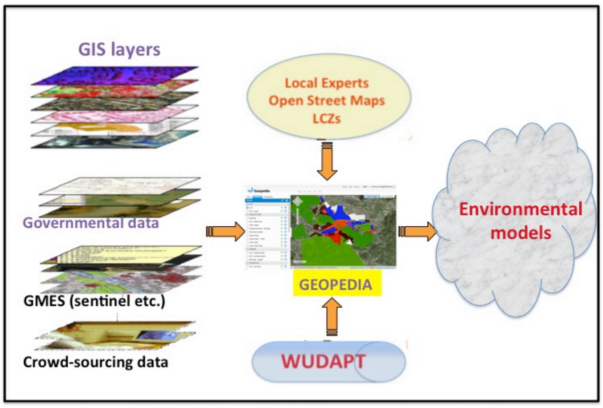

Fig. 7: Geopedia, WUDAPT Portal for database generation methodology, storage and access functions.

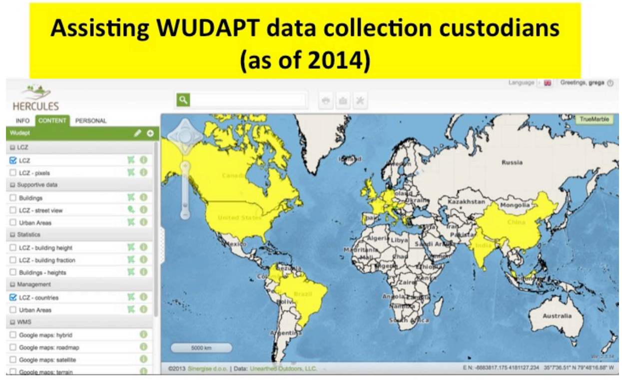

Fig 8: Countries with currently active collaborators for their urban areas in generating WUDAPT current Level "0" data.

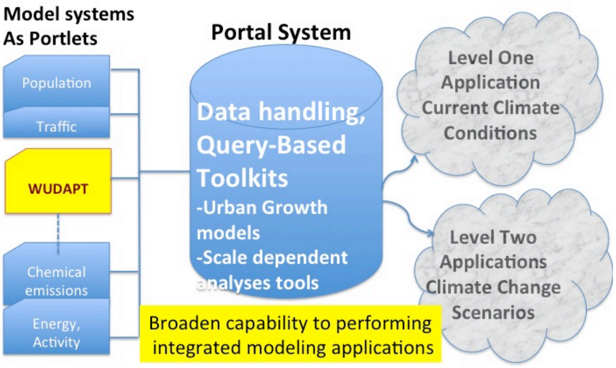

Fig 9: Conceptual hierarchical urban modeling systems incorporating WUDAPT

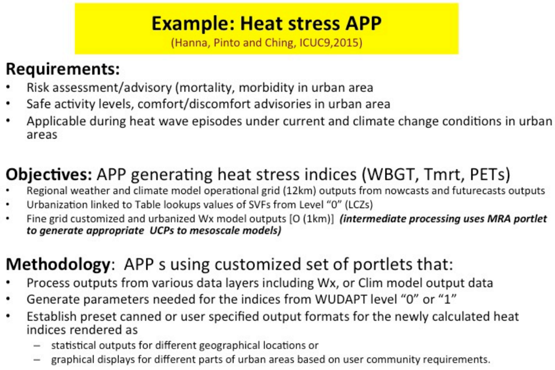

Fig. 10: Example of APP and portal examining heat stress in current and future climates for different LCZ classes.

Models for comprehensive air quality assessments using systems such as CMAQ would be even more complex, (Baklanov et al., 2009) requiring inputs from meteo-climate model outcomes and emission projections. The highest and most comprehensive level of assessment is the systemic modelling system approach (Masson et al., 2014), requiring linking interdisciplinary models including urban growth models to robustly examine adaptation strategies for cities in the context of climate changes (Fig 11a). WUDAPT would make possible all levels of assessments for current and future climate scenarios applicable anywhere on the globe. It is understood that as the levels of applications become succeedingly more comprehensive and complex, it will obviously be critically important to identify and then to engage with stakeholders in establishing and supporting the design purpose and the customized outcomes of these applications. Fig 11b is a conceptualization of a systemic approach as it might be set up by the stakeholders in major urban areas engaged in comprehensively addressing and planning development options to modernize their cities to respond to environmental risks and improved sustainability and the role of modelling tools using WUDAPT by its Scientific Committee. Already, such an approach is underway in France in a Project called Applied Modeling of Urban Climate and Energy project or "MApUCE" www.cnrm.meteo.fr/spip.php?article787) where one of the key stakeholder is the energy community.

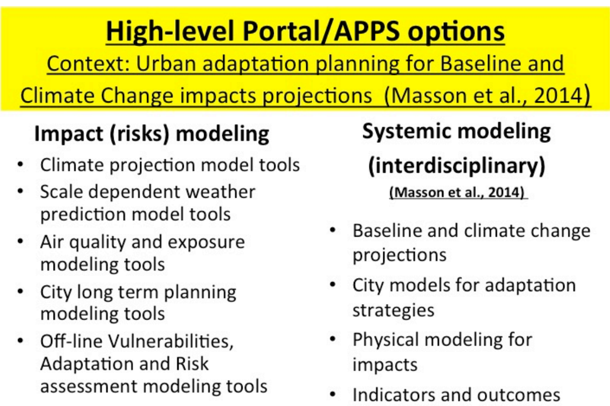

Fig. 11a: Examples of high level APPS including Impact and Risk modeling and comprehensive interdisciplinary assessment modeling tools.

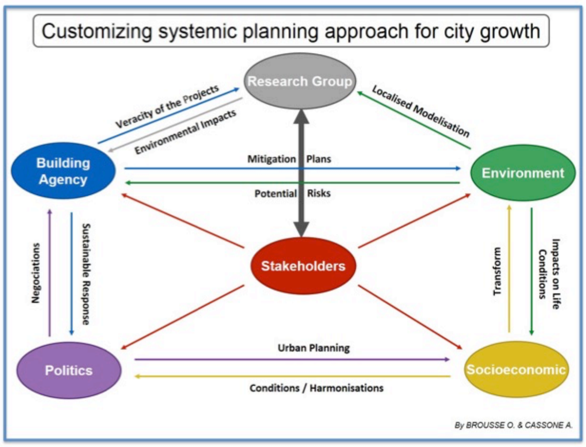

Fig. 11b. Schematic of conceptual systemic type modeling that incorporates WUDAPT information into environmental models (e.g., WRF, TEB by Research Group)

It is possible to consider, theoretically, applications using WUDAPT performed at increasingly higher levels of assessments would be achievable with hierarchical system of models (set up as portals). It is conceivable that, much like with programming, where subroutines are called on to handle routine processing, and interface processers provide links between processing steps, some basic apps could be set up as applets, and links as servlets for the next level of portals requirements of functionality according to industry rules. Such portals would themselves be modified to become portlets (tools) or servlets (linkages) for even higher level applications, in essence becoming a system of systems but structured based on OASIS (Organization for the Advancement of Structured Information Standards) protocols https://www.oasis-open.org. However, implementations along these lines are likely to be long term developments.

4. Summary and Path(s) forward.

WUDAPT is a viable and important venture addressing significant and important aspects of the emerging urban landscape of cities that will be undergoing profound changes in morphological details and implications in city design, adaptation, sustainability, comfort levels and reciprocal impact within and on both the immediate and the global environment. Early efforts and model usage to date are highly encouraging, suggesting a worldwide implementation as feasible. Given the interest and support of those attending the Dublin Workshop in 2014, it is really encouraging; we are optimistic that this interest will continue to grow and others from around the world (Fig 1, 3 and 6) will become interested collaborators as was hoped for in the design implementation concept. One means to expand interest is to follow developments in www.wudapt.org. Much remains to be done, both to achieve full coverage at Level "0", development of protocols and methodologies for Level "1 and 2" and to their development efforts to make possible, the dual requirement of database development and access, as well as for a wide range of APPS and Portals. With this approach, we maximize the potential of this database to a myriad of model application use from local risk assessments to addressing and supporting global policy deliberation and their implications, and to even support future modelling R&Ds. Thus, engaging and maintaining the IAUC involvement (and promoting it to other urban-centric communities and stakeholders) in both aspect of WUDAPT, its database and portal developments, is critically important. Thus we can anticipate WUDAPT to be an important IAUC legacy; individuals can readily participate at many levels, from implementation towards current data gathering with current (and towards improving) methodologies and protocols, to conducting research and analyses using this database, and to working with local and international stakeholders towards the development of "fit for purpose" portals. For the immediate future, we envision taking the following tactical steps:

(1) Towards the goal of full implementation, there will be an opportunity for IAUC participants to engage in a short workshop designed o increase the numbers of cities available at Level "0". The Workshop organizers are motivated to give priority to additional cities preselected to be inclusive of those cities now engaged in the C40 program. Paraphrasing, C40 (www.c40.org) is a global network of large cities (now 75 in number) taking action to address climate change by developing and implementing policies and programs that generate measurable reductions in both greenhouse gas emissions and climate risks. We feel that WUDAPT has potential synergisms and a capability to contribute substantially towards their goals and challenges (and to other organizations with similar goals and needs).

(2) Regarding Geopedia, the current WUDAPT Portal, we will proceed with a set of activity to (a) develop, test and deploy for its role in generating Level 1 and 2 data; (b) identify, incorporate and implement capabilities to process Level "0,1 and 2" data for generating scale dependent model ready urban parameters needed in mesoscale, climate and SEB models; (c) address data repository, quality assurance and documentation requirements; and first applications.

(3) Begin exploring synergisms between WUDAPT and MApUCE (www.cnrm.meteo.fr/spip.php?article787). The MApUCE goals in the next 4 years are: (i) To develop an automated method (in GIS) urban settings for TEB with an energy building model from national databases, urban parameters and indicators (geometric, architectural, socio-economic,) relevant to the energy simulation, and at the neighborhood level in France; and (ii) To integrate such quantitative data in legal proceedings and urban policies. Test cities include Toulouse, Provence and La Rochelle). This "science to policy" project can potentially serve other WUDAPT communities with a template for regional policies towards improving the implementation of energy saving policies and climate management and their integration into Federal planning devices "at the right time, right place, and with the right tool."

(4) Development of a framework for collaboration, resource developments and future projects. We begin with augmenting our existing collaborations with additional volunteer collaborating partners from all the worlds' countries, and to develop a working protocol for this collaboration.

(5) We will seek to develop a set of proposals to parties and stakeholder organizations that would have potential interest in sponsorship.

To conclude, initial efforts are highly encouraging, demonstrating increasing feasibility to achieving the tenets of the WUDAPT community design concepts. Interest is growing and momentum is building towards full implementation. IAUC is invited to continue to help achieve the goals and objectives of WUDAPT; the greater the level of involvement, the greater the overall value WUDAPT to the urban communities. Again, please go to www.wudapt.org and click on "Want to get involved".

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