

Urbanising Deltas of the World Programme 2014 – 2nd Call for proposals Integrated Project - Form for full application

1. Project characteristics

a) Title: Waterapps; Water information services for sustainable food production in peri-urban delta areas in Ghana and Bangladesh.

b) Focus/foci

	1) Resilient urban planning and management
X	2) Optimising water allocation and use in the delta
	3) (Integrated) coastal zone management

c) Duration

60	Months
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d) Main field of research

Code & Field of research: 15.90.00; Earth Science Other

If applicable: other fields of research, in order of relevance

44.10.00; Public Administration. 16.50.00; User Interfaces, Multi Media

2. Composition of the consortium & project staff

a) Consortium members

Main applicant (coordinator)		Co-applicant	
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Title(s):	Dr. ir.	Title(s):	Dr.
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Role in project:	coordinator, PhD/MSc supervision	Role in project:	project team, governance aspects, PhD co-promotor
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Type of organisation*:	Research organisation	Type of organisation*:	Research Organisation
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Co-applicant		Co-applicant	
Family name:	de Groot	Family name:	Boomgaard

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First name(s):	Casper	First name(s):	Marcel
Title(s):	MSc.	Title(s):	Ir.
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Expertise(s):	Risk Management, IT Management and Project Management in the finance industry	Expertise(s):	Beleid en onderzoek regionaal waterbeheer
Role in project:	Management knowledge sharing platform	Role in project:	training and institutional capacity building
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Title(s):	Prof.	Title(s):	ir.
Male/Female (M/F):	F	Male/Female (M/F):	M
Expertise(s):	Irrigation and food production	Expertise(s):	Training and institutional capacity building
Role in project:	co-supervision 2 PhD students	Role in project:	coordination Accra case, institutional capacity building
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Type of organisation*:	Research organisation	Type of organisation*:	business (SME)
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Title(s):	Dr.	Title(s):	prof.
Male/Female (M/F):	M.	Male/Female (M/F):	M.
Expertise(s):	Co-Principal Investigator, Physical Modelling Component	Expertise(s):	Riparian and Coastal Environment: Science and Management
Role in project:	co-supervision PhD	Role in project:	MSc student involvement
Organisation's name:	Bangladesh Centre for Advanced Studies (BCAS)	Organisation's name:	Environmental Science Discipline, Khulna University

Type of organisation*:	Research Organisation	Type of organisation*:	Research Organisation
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Co-applicant			
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Title(s):	BSc		
Male/Female (M/F):	M		
Expertise(s):	Generating, disseminating and implementing of information products. Use of remote sensing data.		
Role in project:	Training and institutional capacity building		
Organisation's name:	Waterschap Aa en Maas		
Type of organisation*:	public organization		
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* Research organisation, business (start-up, SME, established enterprise) or other organisation (public, private, non-profit)

3. Consortium and track record

a) Consortium: roles and added value

Word count: 373

The proposed consortium brings together a diverse range of organisations, ranking from private businesses (both SME and established), to research (universities) and public authorities (water authority, research institute). All share a strong interest in research and production of water availability forecasting in peri-urban delta areas and use of modern information technology. Rabobank has invested in the development of a professional social knowledge sharing network for its rural clients around the world. Rabobank is currently testing its first release, with the intention to roll out to its first rural clients later in 2015. Rabobank wishes to leverage the use of its platform and gain feedback from its users.

The Wageningen University, Earth System Science Group will coordinate this project. This group has a strong track record in management of internationally funded projects and has currently research collaborations with both the Bangladeshi and Ghanaian partners. All academic partners are in the forefront of science in the field of adaptation to climate change in delta areas and food security. Wageningen University and BCAS want to build upon scientific research on seasonal weather forecasting and water availability assessments. All partners consider strong interactions with stakeholders as indispensable for sustainable development. BCAS, University for Development Studies and the two Wageningen University groups all are doing research on citizen science and want to further develop this field. The Bangladeshi and Ghanaian partners will develop case studies around the cities of Khulna and Accra and, of course, will contribute to the generic scientific ambitions of this project. In both cases, partners are involved in research on peri-urban water management in deltas (for instance through contributions to an UNEP funded series of researches on peri-urban agriculture).

The Ghanaian SME, MDF West Africa, aims at using innovation results for training and for its consultancies on institutional capacity building. The Water Authorities 'Hollands Noorderkwartier' and 'Aa and Maas' support the project using its extensive experience with interactions between public authorities and water users in deltas, and want to benefit from research and experiment outcomes on virtual communities for water information services for the organisation of their own information services. The Dutch SME Topshare is not consortium partner, but will be subcontracted to contribute to the design of knowledge sharing platforms and virtual communities.

b) Consortium: track record

Wageningen University, Earth System Science Group

- Haddeland, I., D. B. Clark, W. Franssen, F. Ludwig, F. Voß, N. W. Arnell, N. Bertrand, M. Best, S. Folwell, D. Gerten, S. Gomes, S. N. Gosling, S. Hagemann, N. Hanasaki, R. Harding, J. Heinke, P. Kabat, S. Koirala, T. Oki, J. Polcher, T. Stacke, P. Viterbo, G. P. Weedon and P. Yeh (2011). "Multimodel Estimate of the Global Terrestrial Water Balance: Setup and First Results." *Journal of Hydrometeorology* 12(5): 869-884.
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Wageningen University, Public Administration and Policy

- Buytaert, W., Zulkafli, Z., Grainger, S., Acosta, L., Alemie, T. C., Bastiaensen, J., De Bievre, B., Bhusal, J., Clark, J., Dewulf, A., Foggin, M., Hannah, D., Hergarten, C., Isaeva, A., Karpouzoglou, T., Pandeya, B., Paudel, D., Keskhav, S., Steenhuis, T., Tilahun, S., Van Hecken, G., & Zhumanova, M. (2014). Citizen science in hydrology and water resources: opportunities for knowledge generation, ecosystem service management, and sustainable development. *Frontiers in Earth Science*, 2(October), 1–21. doi:10.3389/feart.2014.00026
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- Dewulf, A., Craps, M., Bouwen, R., Abril, F., & Zhingri, M. (2005). How indigenous farmers and university engineers create actionable knowledge for sustainable irrigation. *Action Research*, 3(2), 175–192. doi:10.1177/1476750305052141
- Dewulf, A., Craps, M., Bouwen, R., Taillieu, T., & Pahl-Wostl, C. (2005). Integrated management of natural resources: dealing with ambiguous issues, multiple actors and diverging frames. *Water Science and Technology*, 52(6), 115–24.

Rabobank

As the world's leading food and agribusiness bank, Rabobank has a strong commitment to research and knowledge sharing for the entire food and agri chain. Rabobank is developing a professional social knowledge sharing network for our rural clients around the world. Its rural clients will use the platform to share and discuss knowledge among their peers.

Rabobank is currently testing its first release among 100 staff, with the intention to roll out to its first rural clients later in 2015.

Water Authorities 'Hoogheemraadschap van Hollands Noorderkwartier' and 'Aa and Maas'

These regional water management authorities are responsible for flood control, water quality and quantity and the treatment of urban wastewater. Regional water authorities are

legally embedded in the overall democratic structure of the Netherlands and they are experts in the field of water governance. Emphasis is put on finding smart, innovative solutions to water problems, but also on generating support for those solutions, in involving stakeholders and in organising the management of those solutions. The Organisation for Economic Cooperation and Development (OECD) qualified Dutch water management as a 'global reference' and praised the effectiveness of Dutch water management and the role of the regional water authorities.

University for Development Studies

- Effah K. Antwi, Kei Otsuki, et al. (2014) Developing a Community-Based Resilience Assessment Model with reference to Northern Ghana. *Journal of Integrated Disaster Risk Management* 4(1) DOI10.5595/idrim.2014.0066
- Victor Lolig, Samuel A. Donkoh et al. (2014) Households' Coping Strategies in Drought- and Flood-Prone Communities in Northern Ghana. *Journal of Disaster Research* Vol.9 No.4
- Unami, Koichi, et al. "Case study: hydraulic modeling of runoff processes in Ghanaian inland valleys." *Journal of Hydraulic Engineering* 135.7 (2009): 539-553.
- Gordana Kranjac-Berisavljevic, Shayibu Abdul-Ghanyu, Bizoola Zinzoola Gandaa, and Felix K. Abagale (2014) Dry Spells Occurrence in Tamale, Northern Ghana – Review of Available Information. *Journal of Disaster Research* Vol.9 No.4
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Bangladesh Centre for Advanced Studies (BCAS)

- Wesselink, A. Warner, J. Syed, M.A. Chan, F. Tran, D.D. Huq, H. Thuy, N.L. Staveren, M.V. Wester, F. and Zegwaard, A. 2015. Soft flood risk management in deltas around the world: can we learn lessons from comparison? Special Issue by Jacobi/Empinotti/Warner of *International Journal for Water Governance*, paper accepted In Press
- Rahman, A. Syed, M.A. Nabi, A.K.M.N. Mirza, M.Q. Hossain, M. Mamnun, N. Rahman 2014. Building Urban Resilience: Assessing Urban and Peri-urban Agriculture in Dhaka, Eds. John Padgahm, United Nations Environment Programme (UNEP), November 2014
- Syed, M.A. 2015. Regional analysis, import-export and related issues on food security, Chapter 7 in *Food Security and Risk Reduction in Bangladesh*, Eds. Umma Habiba, Md. Anwarul Abedin, Abu Wali Raghieb Hassan, Rajib Shaw, Springer Japan KK, Tokyo In Press
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- Matin, N. Syed, M.A. Musingo T. E. Mbuvi, Odit, B.O. and Ongugo, P.O. 2014. Group Inequality and Environmental Sustainability: Insights from Bangladesh and Kenyan Forest Commons, *Sustainability*, Vol. 6, 1462-1488; doi:10.3390/su6031462

Khulna University

- Khan MSA, Mondal MS, Rahman R, Huq H, Datta DK, Kumar U and Jalal MR (2014) Urban Burden on Peri-urban Areas: Shared Use of a River in a Climate Change Vulnerable Coastal City. In *Peri-urban Water Security: Insights from South Asia*, Oxford University Press (accepted)
- Khan MSA, Mondal MS, Kumar U, Rahman R, Huq H and Datta DK (2013) Climate Change, Salinity Intrusion and Water Insecurity in Peri-urban Khulna, Bangladesh. In , A Prakash and S Singh (eds) *Water Security in Peri-urban South Asia: Adapting to Climate Change and Urbanization*: pp 9-30, SasiWATERs and IDRC, Hyderabad, June 2013
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Urban Geology: A Case Study of Khulna City Corporation, Bangladesh. *J. Life Earth Sci.*
1(2): 17-29

MDF West Africa

MDF West Africa is a Ghana based independent SME providing training and consultancy services to countries in West Africa (see: www.mdf.nl/mdf-offices/mdf-west-africa/welcome-to-mdf-wa/). This branch focuses on facilitation of organisational learning aiming to improve organisations' effectiveness, relevance and social impact. It is part of the Dutch MDF consultancy and training company network (see www.mdf.nl/).

4. Summary of the project proposal

Word count: 246

Water for agriculture in peri-urban delta areas is vital to safeguard sustainable food production. Due to dynamics of urbanisation in deltas and climate change, water availability (too much, not enough, too late or early) is becoming erratic and farmers cannot rely only on their own experience anymore to plan farming operations. This research aims to develop tailor made water information services with and for farmers in peri-urban areas in the urbanising deltas of Accra, Ghana and Khulna, Bangladesh to improve water and food security in river deltas. This will be done by 1) combining mobile information technology (like apps) with latest insights on knowledge sharing; 2) integrating weather model results with observations of groundwater trends and river flows; and 3) attuning knowledge about adaptive decision making and enabling governance structures to local situations. These insights will be used to co-create and test water information services, consisting of knowledge sharing platforms and virtual communities. Enabled by NWO seed money, the consortium has organised workshops with key actors (farmers, governance actors and ICT professionals) in both areas. These stakeholders have contributed to this proposal and are committed to engage in the proposed research and innovation process. The co-production of water information services with local farmers will empower and improve livelihoods of small/medium farmers and build capacity for enhancing sustainable food production. Furthermore it will result in a business case by delivering design principles for viable farmer-oriented water information services in other urban-rural delta zones in the developing world.

5. Reporting on proposal development workshop

a) Summary

Word count: 486

Two stakeholder workshops the first in Khulna (Bangladesh) on May 31st and June 1st, and the second in Accra on June 30th were held with the following objectives:

- Appraisal of information needs on water availability in the two case study areas;
- Stakeholder involvement;
- Sustainability of knowledge sharing platforms and virtual communities.

Appraisal of Information needs.

The Khulna peri-urban area's approximately seven thousand farmers, produce vegetables, fruits, rice, fish and shrimps. The farmers are affected by water logging due to human induced changes in drainage systems and sea level rise, also salt water intrusion in both surface and groundwater is a problem. Most households are suffering from food crisis whereas they used to be a food surplus region.

The Greater Accra Region (GAR) encompasses two river deltas (the Volta and the Densu). Agricultural activities take place in the flood and delta plains and produce fruits and vegetables for the city and fruits (mango, banana, pineapple) for export markets. Recently observations suggest rainfall is becoming more erratic, and farmers cannot predict the rainfall as they used to and loose seed (by sowing several times) and eventually, their harvest.

There is a need in both case study areas, for tailor made and dynamic predictions of rainfall, river discharges, salt intrusion and groundwater tables. Current information on water availability exists within governmental agencies, but there are challenges with fragmentation, forecasting time and spatial resolution. Bangladesh has experience with internet use in flood forecasting (see <http://ais.gov.bd>) but in both countries information is reaching farmers with difficulty. Lack of farmer's knowhow and local languages complicate the use of generic English internet platforms. A strategy is to use ICT technology and connect these with SMS services and local radio stations to improve timely information provision. And to use farmers associations (Ghana) and Union Information Centers (Bangladesh) as intermediate organizations.

Stakeholder involvement.

Individual farmers and farmers organizations expressed their wish to collaborate with this research by providing access to their fields, by providing observations, and by testing information services. Meteorological and water management institutes possess relevant data and institutes expressed their interest to collaborate with this research and provide access to data.

Sustainability.

After having finalized the research programme, the information services can be taken over by a government agency (in Khulna the Department of Agricultural Extension (DAE) showed interest) or a commercial party like one of the participating ICT companies. Payment by farmers is probably not viable, but insurance companies may be willing to pay for data. The ICT platform as we see it now, is probably outdated in 2021. To better guarantee sustainability, the project will organize training and capacity building of farmers (to enhance their capacity to update information services) and information providers (to close data gaps and to integrate different data sources). South – south exchanges between Ghana and Bangladesh was suggested as an additional added value of this project. (see annex 4 for photos and more information).

b) Participants

Workshop Stakeholders		y/n	Name, organization and country	Level of engagement	
1	Academics	y	Khulna University, Bangladesh. University for Development Studies (Accra, Ghana). Wageningen University. University of Ghana (IESS)	Co-applicant, member of the project board, potential PhD candidate Coordinator collaboration in exchange of students	
3	Research	National	y	Bangladesh Centre for	Co-applicant, member of the

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	institutes			Advanced Studies (BCAS)	project board
Workshop Stakeholders IP			y/n	Name, organization and country	Level of engagement
2	User Groups		y	Farmer (Khulna, Bangladesh) Fish Farm owner (Khulna, Bangladesh) Small vegetable farmers association (Ghana) Golden Exotics (bananas and pineapple production for export) (Ghana)	co-construction of knowledge; consultation during field level study; provide information based on their own observation
3	Extension Organization		y	Department of Agricultural Extension (DAE), Bangladesh	Will be a stakeholder partner and part of knowledge sharing platforms and research uptake; A potential agency that can host the Waterapps
7	NGO	Local	y	Jagrata Juba Shangha (JJS), Khulna (Bangladesh)	Will be involved knowledge sharing platforms and uptake of research findings
9		International	y	World Vision Bangladesh	Will be invited to stakeholder meetings and knowledge sharing platforms
10	Private for profit sector entity		y	MDF WA consultancy (Ghana) Nalo Solutions (ICT company) (Ghana) SVFeta (ICT company (Ghana) Aippnetworks (Ghana) EHSolutions (ICT company Ghana)	Co-applicant, member of the project board Interest in ICT platform construction Interest in ICT platform construction Interest in ICT platform construction Interest in ICT platform construction
11	Public institute, agency or committee		y	Ghana Meteorological Agency Water Resources Committee (Ghana) Water Authority Aa and Maas (Netherlands, in Ghana)	provision of weather and water data, involvement in ICT platform, interest in training Co-applicant, member of the project board
15	Government institute	National	y	Department of Public Health Engineering (DPHE) (Bangladesh)	Will provide data and information on ground water and water quality; uptake of research findings
17	Others, namely: community organization		y	Pani Parishad (Bangladesh)	Will participate in co-construction of knowledge consultation during field level study

6. Description of the project

Word count: 2985

a) Background and innovation opportunity

Cities of the world are rapidly growing, especially in deltas, and it is in the periphery urbanisation where rural to urban transformations take place. [1] This peri-urban interface is characterised by strong environmental, land ownership and other livelihood dynamics resulting from rapid land use changes and population growth and by emergence of new markets, services and labour [2]. Consequently agricultural systems in these transitional areas are facing complex environmental risks and development challenges. However, they also offer opportunities through the creation of new value chains for urban market oriented agricultural products [3].

Claims on water resources in these areas, and especially in urbanizing deltas, are highly complex. Water is needed for local agricultural communities' s irrigation, households and sanitation. But, expanding urban areas often get priority in water delivery [4]. In addition, urban areas affect peri-urban water systems through the transfer of polluted water from sewage systems and retention of storm water run-off [5]. Water quality decline in peri-urban areas can pose serious concerns for food security [6, 7]. Specific delta water characteristics like: floods originating from rivers and marine waters, salt water intrusion, high groundwater tables add to the mentioned food security concerns [8, 9]. These concerns are aggravated by the positioning of most peri-urban agricultural fields at city margins, in low laying flood prone areas.

Planning of farming activities (e.g. choice of crops, planting date, irrigation, etc.) in developing countries, used to rely heavily on experiential knowledge of climatic patterns, variability and on knowledge on local water sources. Farmers did possess valuable knowledge for example on when the first rains arrive and how much water is likely to become available and when to expect floods. However, climate change in combination with the mentioned intensification of water use is making farmer predictions increasingly uncertain [10, 11, 12].

Stakeholder workshop participants in Khulna and Accra (see chapter 5) underlined the importance to support farmers with other types of knowledge to enhance their capacity to assess water availability risks. Useable information services do not yet exist, but are essential to help them to make better informed decisions. Decisions that ultimately result in improvements in livelihood strategies of poorer peri-urban farmers and higher food security.

The WMO (<http://www.bom.gov.au/wmo/lrfvs/>) and IRI (<http://iri.columbia.edu/our-expertise/climate/forecasts/seasonal-climate-forecasts/>) are presenting state of the art seasonal forecast data on the internet. Research programs like Euporias [13, 14] (<http://www.euporias.eu/objectives>) develop methods and tools to translate these data into useable climate services for the agricultural and water sector. The word 'services' however implies a healthy exchange between service providers and users, but in the current practice of provision of climate and weather information active data users are largely missing and it is often a one-way process [15]. This means that the potential for production and use of water availability forecasts is underdeveloped. Creating a setting were users understand the possibilities and limitations and contribute to production of forecast information is an important challenge.

We therefore see innovation potential in the making of tailor made and dynamic water availability forecast information services, for peri-urban agriculture in urbanizing deltas, through the use of knowledge sharing platforms and virtual communities. This potential is based on three elements: 1; Opportunities resulting from the rapidly growing use of modern information technologies in developing countries [16, 17, 18,19]. This digital revolution enables participants to both contribute to and benefit from improved access to relevant information. 2; Advances in climate science in the field of climate and weather forecasts, allowing for downscaling and tailoring of information to user needs and integration with water availability for food production, groundwater levels and salt intrusion [13, 14, 20, 21, 22]. 3; Contributing to farmers decision making capacity to adapt to changing environmental conditions [23, 24, 25].

b) Project objective(s)

This research aims to develop tailored water information services with and for farmers in peri-urban areas in the urbanising deltas of Accra, Ghana and Khulna, Bangladesh to improve water and food security in urbanizing deltas.

Its contributions to the three UDW objectives are:

1. Research & Knowledge generation: Integrate forecasting methods and knowledge sharing concepts into tailored information services to enable adaptive decision making.
2. Innovation & Business development: Develop design principles (business case, governance arrangements, technical principles, scientific conditions and uncertainties) for tailor made water information services for farmers in peri-urban areas in urbanising deltas.
3. Sustainable & Inclusive development: Organise inclusive processes resulting in two functional knowledge sharing platforms and virtual communities actively engaging farmers, farmers associations and other stakeholders in the Khulna Bangladesh and Accra Ghana delta area. Thus empowering small and medium farmers and enhancing food security in these areas and proposing design principles for similar platforms and communities in other delta areas.

c) Research outline

To develop tailored water information services we need to address knowledge gaps in three components of our research proposal (see figure 3). The research integrates these components through the co-production process in two case study areas. These case study areas were selected with the aim to provide us with a reasonable empirical basis for reaching generic conclusions. The cases therefore must have different conditions. The following selection criteria were used:

- Peri-urban areas in delta regions with water availability (drought, flood) problems [3, 27, 33, 34];
- Existence of information technology and acceptable density of smart phones [29];
- Water partner countries of Dutch development corporation;
- Front running countries in digital development in their regions;
- Different governance contexts.

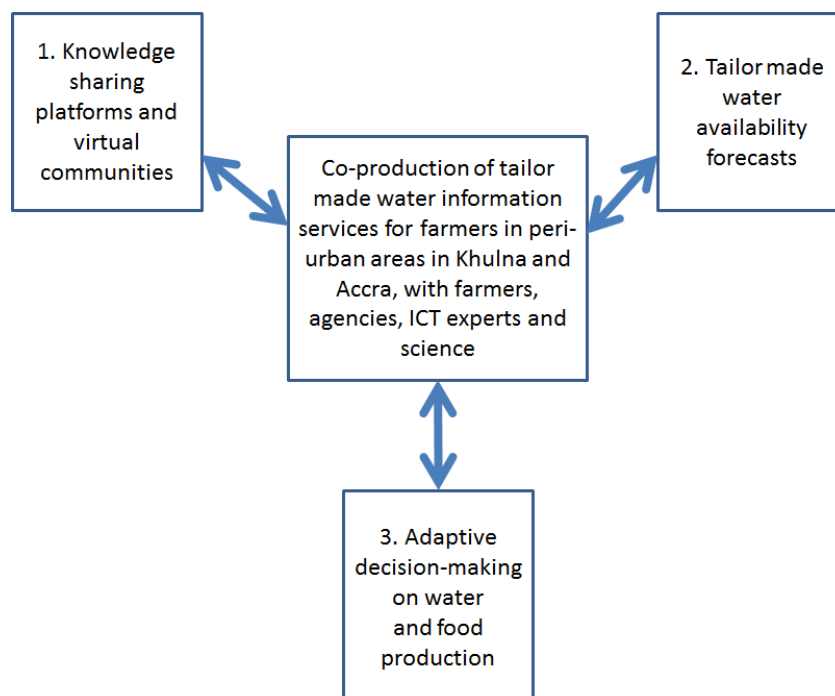


Figure 3: main components of this research

The first component is the use of innovations in information and communication technologies enabling **knowledge sharing platforms and virtual communities**. We already see large numbers of water-related information services in the developed world. But also in developing countries, mobile phone technology is witnessed to be rapidly expanding. Bangladesh is, for example, experimenting with mobile phones and websites for flood warnings [26] and has established payment systems by text message, and Ghana uses the technology for environmental monitoring [27] and livelihood development [28].

A characteristic of these technologies is the introduction of possibilities for interaction. Involvement of non-experts in virtual knowledge sharing arrangements is growing. An example is the Dutch 'Nature Calendar' (<http://www.natuurkalender.nl/index.asp>) where citizens upload biological observations, such as: flowering time of plants, migration of birds, etc. Leveraging these forms of science-practice interactions - called citizen science – towards development orientated goals is a growing topic of scientific research [23, 24, 25, 26]. The use of such interactive approaches in water management is in an initial stage of development.

The second component is the rapidly evolving capability to **forecast weather on longer than two week time horizons**. [20, 21, 32]. Tailor made forecasting (uptill seasonal forecast) has improved in the last decade and the skill is now high enough to be of possible use for water management in variable climates. Most of the current products, however, give very large scale information. There is need to develop tailored information services products at more local scale to ensure that farmers can use the forecasts [13, 22] and to integrate model output with local hydrological parameters, like river discharges, groundwater levels, salt water intrusion. And translate model outputs (including understand of variability, uncertainties and data and model limitations) into understandable and useable information for non-experts.

The third component addresses the possibilities for exchange of information and interaction offered by ICT technologies having potentially transformative implications for **adaptive decision-making** [26] on water and food production, and for **governance arrangements** enabling this. Individual farmers take decisions on which crops to grow, when and how much to irrigate or which agricultural inputs and technologies to use. Collective decision-making by communities, irrigation organizations, local, regional or national governments plays an important role as well, by creating some of the opportunities and constraints for individual farmer decision making [27, 28, 30]. Many of these decisions need to be made under high uncertainty and must adapt flexibly to constant changing conditions. Often crucial information or knowledge is lacking, due to knowledge gaps, limited information availability or access problems for disadvantaged groups. Scientific advances in water availability forecasting provide new possibilities for conveying information and associated uncertainties, add value by combining global and local data, and provide information ranging from real-time monitoring to seasonal or long term forecasts.

If we can better understand what: 1). makes decisions on crops and irrigation more adaptive, and 2). what kind of governance arrangements are needed to enable effective generation and sharing of digitalized information among the key actors, we will be better able to design and institutionally embed water information services. Knowledge sharing platforms and virtual communities provide an important set of tools for enhancing information sharing, engagement and interaction between individuals, organizations, agencies at multiple governance levels by strengthening monitoring, measurement, and collection of environmental information [23, 31].

The stakeholder workshops (see chapter 5) have resulted in water availability information needs and in commitment from stakeholders to collaborate with researchers. These needs and the co-production process of tailored water information services (see figure 3) are the integrative forces of this research. It is through this that the scientific contributions in the three components will be guided and which shapes the interdisciplinary character of this research.

The resulting overall research question is:

How can the potential of water availability forecasts and knowledge sharing platforms and virtual communities be leveraged to create water information services that support adaptive decision-making about water and food production in the peri-urban delta areas?

Sub questions are:

- RQ1. How can existing sources of seasonal weather forecasts data be scaled at optimal resolution and quality for the peri-urban delta areas?
- RQ2. What field observations can reinforce model results on seasonal weather forecasts?
- RQ3. What are the information needs of water users in peri-urban agriculture, and what conditions motivate water users to actively contribute to the knowledge sharing platforms and virtual communities?
- RQ4. How can water information services support adaptive decision-making about water and food production in peri-urban delta areas?
- RQ5. What governance and financial conditions enable the sustainable functioning of water information services?

The research is organized in 6 work packages (see figure 4)

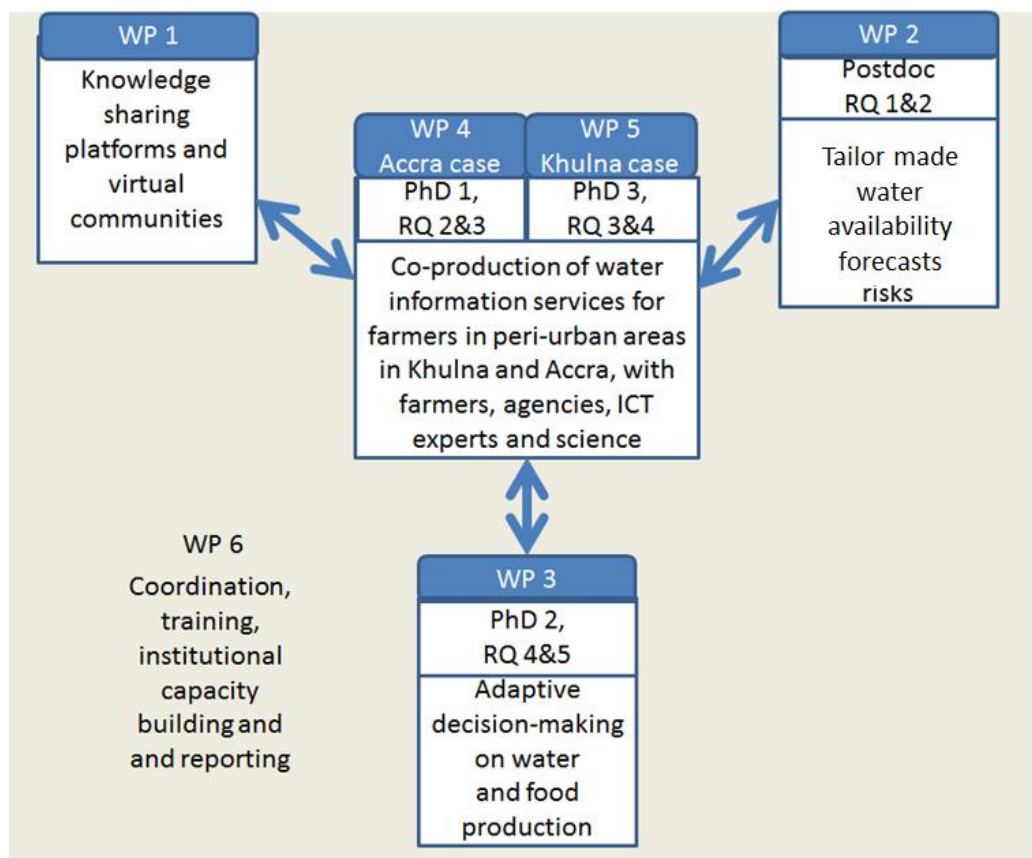


Figure 4. Work packages (WP) in relation to research components (see figure 3) , research questions (RQ) and PhD's.

Work Package 1. This work package delivers the technological conditions for knowledge sharing and virtual communities. The knowledge sharing platforms in the case study areas will use Rabobank's 'Enabling Farmers' internet platform. This internet platform is developed for clients in Australia and its content will be adapted for use in Accra and Khulna.

The stakeholder workshops (chapter 5) showed that combining virtual communities with internet, SMS services and local radio may be the best option. To ensure the best possible design we propose to contract a specialized information technology consultant, called Topshare (see www.topshare.com).

Knowledge sharing platform data are provided by WP 2 and the virtual communities are managed in WP 4 and 5.

Work Package 2 contributes to research question 1 and 2 and develops tailored forecast information for the two case study areas. Large scale climate and weather forecast model output with sufficient skill will be downscaled and combined with local observations and existing local and regional model output to develop the required water availability information. For integration of the data at the case study level, simple models (based on GIS of the case study areas and, depending on needs, coupled with hydro-agricultural modules) will be developed. The local observations will include components such as temperature, precipitation, groundwater levels, soil moisture and /or plant biomass. The local observation is used to calibrate and validate the model and improve the usefulness of the tailor made forecast products. The developed forecasting information will be evaluated together with local stakeholders in WP 4&5.

This work package has to manage the risks of integrating data from several sources having different qualities and spatial and temporal resolution characteristics. To manage this risk an experienced researcher with modelling skills (postdoc) will take the lead.

Work package 3 contributes to research questions 4 and 5 and focusses on adaptive decision-making on crops and irrigation in peri-urban agriculture. The research takes place in the Greater Accra Region case study, but will also integrate results from the Khulna case study area (through field study in Khulna). This work package will work closely together with work package 4 (the Accra case study) in information needs assessment and focus on the analysis of individual and collective decision-making processes through qualitative analysis of interviews with key informants, policy documents and participant observation. Institutional analysis will create knowledge about the embedding of water information services in local to national governance arrangements for water management and food production.

Risks in data collection are the willingness of farmers to engage in interviews and to share knowledge (overkill of NGO interventions has resulted in resistance to participate). Farmers at the stakeholder workshop (chapter 5) want to collaborate, but we do not know about other communities. But we are confident that our current contacts will support us in establishing new contacts.

Work Package 4 and 5 contribute to research questions 2, 3 & 4. In each of the case study sites the knowledge sharing platforms and virtual communities on water availability will be operationalised by engaging with farmers and farmers associations and other stakeholders and by leveraging the technology.

Both cases entail PhD research on the development process and functioning of knowledge sharing platforms and virtual communities. Evolving information needs of users of water information services and the design and functioning of knowledge sharing platforms and virtual communities will be monitored and analysed. Protocols for field observations on weather, groundwater and water quality are made. And the impact of water information services on decision making on water and food production in the case study areas will be studied (together with WP3).

Awareness of ethical issues related to privacy of interviewees (see our data management plan in chapter 10) and (un)equal access to information influencing equitable development of especially small farmers and gender balances are part of the research approach.

In this work package field study observations combine with qualitative analysis of interviews, participant observations and (virtual) group discussions.

Work package 6 entails project coordination, reporting of synthesis of results and institutional capacity building. Within this work package and in collaboration with the two Dutch Water Authorities (Hollands Noorderkwartier and Aa and Maas) and MDF West Africa training modules and institutional capacity building activities will be developed (see chapter 9).

Ethical considerations

Besides ethical considerations related to the case studies (see work package 4 and 5) the Waterapps research will adhere to universal concepts of justice and equity and incorporate the principles of respect for persons, the autonomy of the individual and the environment. The primary ethical consideration is respect and cultural sensitivity for the wide range of stakeholders Waterapps will work with. Throughout the project life all attempts will be made to ensure equal opportunity in engagement with any external partners or researchers and participants. All efforts will be made so that no researchers or their assistants at any level fabricate or falsify data in their activities, analyses or publications. In addition, researchers will not present the work of others as their own, or fail to give appropriate credit for the work of others through citations.

Content of the knowledge sharing platform and the virtual community will be free for publicity. Users of these tools will be warned upfront. Content will not be commercialized, only the design principles are free for companies to further develop business. Rabobank has agreed to free publicity of the Waterapps version content of her Enabling Farmers platform. Design of trainings and courses will be commercialized by MDF West Africa. The content of these courses is free for publicity.

Model data output will be published on our open website and are free for publicity (see chapter 10).

Sustainability

Sustainability was discussed at the stakeholder workshops (see chapter 5). After further discussions we see two promising options:

- 1). After project finalisation the water information services are transferred to participating government agencies. In Bangladesh the Department of Agricultural Extension has already expressed interest in taking over and upscaling the services. In Ghana the Meteorological Agency is a potential candidate.
- 2). Training and capacity building to enable farmers and other stakeholders to continue developing and using water information services, without transferring the project ICT platforms (which will probably be outdated in 2021).

During project lifetime both options will be further explored and developed together with stakeholders.

d) Planning & division of tasks

The gantt chart presents a detailed list of activities with responsible consortium members.

Table: tasks and planning. (WU= Wageningen University, UDS= University for Development Studies, UK= University of Khulna. Topshare is a contracted SME.

activity	responsible	contribute	Y1	Y2	Y3	Y4	Y5
WP 1							
1.1 coordination WP 1	Rabobank	WU					
1.2 access to Enabling Farmers	Rabobank		X				
1.3 Knowledge sharing platform management	Rabobank						
1.4 Tailoring of information on platform	WU Postdoc	UDS, UK, Topshare	X	X	X		
1.5 Processing feedback from case study areas	WU Postdoc	UDS, UK		X	X	X	
1.6 Analysis governance, business case	WU	UDS, UK, Water Authorities					
WP 2							
2.1 coordination WP2	WU						
2.2 data collection metereological agencies	WU Postdoc	UDS, UK					
2.3 processing of local data and observations	WU Postdoc	UDS, UK					
2.4 downscaling relevant climate and weather models	WU Postdoc						
2.5 simple model construction for case study areas	WU Postdoc						
2.6 calibration and validation of models	WU Postdoc						
2.7 final testing and tailoring of information	WU Postdoc	UDS, UK					
WP 3							
3.1 Coordination WP3	WU						
3.2 information chain analysis	PhD 2	WU & UDF					
3.3 analysis of decision making	PhD 2	WU & UDF					
3.4 institutional analysis	PhD 2	WU & UDF					
3.5 integration of Khulna case results	PhD 2	WU & BCAS					
3.6 financial and governance analysis of platforms	WU	all partners					
WP 4&5							
4.1 coordination Accra case study	MDF West Africa	WU					
4.2 coordination Khulna case study	BCAS	WU					
4.3 field observation protocols	PhD 1 & 3	WU & BCAS & UDF					
4.4 information needs inventories	PhD 1 & 3	WU & BCAS & UDF					
4.5 design of virtual community platforms	PhD 1 & 3	WU & BCAS & UDF & Topshare					
4.6 monitoring of virtual communities	PhD 1 & 3	WU & BCAS & UDF					
4.7 monitoring of platform functioning	PhD 1 & 3	WU & BCAS & UDF					
WP 6							
6.1 project coordination	WU	Water Authorities					
6.2 reporting (midterm, final)	WU	all partners			X		X
6.3 training development	WU	MDF West Africa, Water Authorities					
6.4 institutional capacity building	WU	MDF West Africa, Water Authorities					
Research uptake (see chapter 9)							
7.1 PhD training in research schools	WU						
7.2 MSc thesis students supervised	WU, KU, UDF	University of Ghana (no consortium)					
7.1 fully operational knowledge platforms	WU	Rabobank, Topshare				X	XXX
7.3 public website	WU						
7.2 monitoring and capacity building workshops	MDF West Africa	all partners		X	X	X	X
7.3 scientific publications	universities						
7.4 PhD's completed	WU						X

Organization

Wageningen University is project coordinator. A project team (see chapter 2) in Wageningen will take care of daily management, reporting etc. The postdoc is part of this team and is employed by Wageningen University. The sandwich PhD's will receive a Wageningen University PhD diploma, but two are co-supervised by UDF in Ghana and employed in Ghana and one is co-supervised by BCAS in Bangladesh and employed in the same country. This project has an important institutional capacity building component. (see chapter 9) Training development will be coordinated by MDF West Africa and exchange of MSc thesis students will be arranged among the participating universities.

Another component is the development of ICT technologies (knowledge sharing platform and virtual communities). Rabobank contributes with its existing Enabling Farmers platform, but tailoring will be needed and the virtual communities need to be designed. For expert support in this field we propose to contract a specialized consultant: Topshare (www.topshare.com). This SME has extensive experience in citizen science related ICT development and additionally – in case of need - local ICT companies will be subcontracted.

Overall governance of the project is organized through a project board (see annex with draft consortium agreement). This board will convene once a year to discuss progress, problems, planning etc.

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8. Research Impact Pathway & Theory of Change

a) Research Impact Pathway (indicators in italic)

Outputs

Research & knowledge

3 sandwich PhD research projects

- *PhD completed*

Scientific publications addressing the research questions.

- *10 peer-reviewed papers published*

MSc thesis student involvement in research

- *min. 5 MSc thesis completed*

2 integrated water availability forecast models

- *forecast model skill assessment reports*

Information needs assessment and institutional analysis

- *2 reports*

field observations, interviews and participant observations in case study areas.

- *Protocols and reports in data management system.*

Innovation & business

Design principles for water information services in deltas

- *Report and publication in scientific and professional journals*

Active business involvement in project

- *Rabobank, MDF West Africa and Topshare involvement till project end*

Sustainable & inclusive development

Two knowledge sharing platforms and two virtual communities on water availabilities operational

- *Min. 200 farmer user registrations*

Training material for use in urbanizing deltas Improved farming conditions through better adaptive capacity

- *Min 3 trainings or courses given*

Outcomes

Research & knowledge

Enhanced scientific knowledge on integrating multiple data sources for seasonal and tailor made water availability forecasting for farmers.

- *10 citations of Waterapps scientific publications*
- *international adaptation conference contributions (4) on Waterapps results*

Citizen science interactively incorporated in generating tailor made weather forecasts.

- *Continued farmer involvement after project end*

Implementation of new governance arrangements for water information services in developing countries.

- *2 new governance arrangements*

Innovation & business

Water information services modelled on Waterapps project example

- *2 new initiatives in other deltas*

Commercial valorization of trainings and courses

- *4 new trainings outside Waterapps context*

Improved relations among business and innovation partners in three countries.

- *1 new project initiative with consortium scientists and business*

Sustainable & inclusive development

Enhanced institutional capacity for research and innovation in Bangladesh and Ghana.

- *Upscaled use of Waterapps results*

Enhanced capacity of farmers in peri-urban areas to anticipate with seasonal water availability (drought, salt intrusion, groundwater levels, floods).

- *Farmers satisfaction through survey in evaluation phase*

Impact

- Higher adaptive capacity of peri-urban agricultural sector in deltas towards droughts, floods, over-use, pollution and salt intrusion.
- More sustainable and profitable peri-urban delta food production systems.
- Easy and equitable access to information services for different farming systems.
- Innovation in adaptive governance to enhance resilience of societies for environmental shocks.
- More innovation and business in the field of water information services.

b) Theory of Change

Problem area. In urbanizing deltas the complexity of water management is high because existing river, groundwater and coastal water flows need to be managed in relation to the dynamics of land use and population growth. This complexity is best felt in agricultural zones, where urban water use meets (or clash) with rural water use and is aggravated by climate change. The two stakeholder workshops (see chapter 5) showed that, among other problems (like land use rights, pollution), growing uncertainty about water availability (such as start rainy season, flood risks, water levels), is one of the important problems felt by farmers, because it leads to yield problems and food insecurity.

Causes. Farmers used to rely on experiential knowledge to assess the availability of water for food production. And this proved an acceptable basis for decision making on agricultural activities. But things are changing so fast that experience alone is not enough anymore. Climate change and human induced changes in water systems (like land reclamation, excessive groundwater extraction) cause unexpected and unwanted effects. Competing claims on water in peri-urban agricultural zones combined with complex and often chaotic governance contexts in peri-urban zones aggravate the situation.

Underlying knowledge related causes. In both Bangladesh and Ghana meteorological services and water management agencies possess data and do provide information services on water availability. However these services are fragmented and show gaps and problems with temporal and spacial scales and quality differences. Translating such data into relevant and understandable information for farmers, requires complicated integration and dissemination efforts.

Much money and research effort is invested in global and regional climate and weather information portals, but downscaling and tailoring information to a level that farmers understand the value and the limitations and can use it is still a challenge.

To create salient, credible and legitimate information interaction between science, experts and users is necessary. Only through intensive interaction the right 'language' and trust will emerge and only then the governance of information supply can be embedded in local institutions. Recent developments in web-based and mobile technologies present opportunities to organize virtual communities. They allow linking science-based models with participatory monitoring and broad information accessibility. ICT-based virtual platforms enable and encourage users to share relevant environmental information such as the observation of water availability. However, challenges exist regarding data quality, operational reliability, effectiveness and equity to end-users' sustainable access, integration of different bodies of knowledge, or adaptation to user needs and capacities.

Outputs. This project delivers knowledge sharing platforms for peri-urban agricultural zones in the Khulna and Greater Accra Region deltas. These platforms provide farmers with the required salient, credible and legitimate water information. Interactions take place in virtual communities organised with modern ICT technologies (websites, apps) and connected to local communication practices like: SMS/text services and local radio stations operating in local languages and actively engaging with local farmers communities. These facilities will become a structural water information service in the two case study areas. But they also serve as an experimental basis for scientific output and for the development of design principles and business case and institutional capacity development.

Outcomes. Water availability information enhances the adaptive capacity of farmers in the Khulna and Greater Accra Region peri-urban delta areas to anticipate on seasonal water availability (drought, salt intrusion, groundwater levels, floods), thus reducing livelihood vulnerability in farmers communities and improving food security in the deltas.

Impact. Innovations in data and information, ICT and governance aspects of knowledge sharing platforms and virtual communities contribute to higher adaptive capacity of peri-urban agricultural sector in deltas towards droughts, floods, over-use, pollution and salt intrusion and to more sustainable and profitable delta food production systems. Also effective use of water for agriculture will, because of the high relative share of agricultural water in total water use volumes, impact on water use in general and lead to more effective use of fresh water resources in deltas.

Conclusion. Our theory of change is that tailor made water availability information services are used by farmers, reduce uncertainties and enhance farmers adaptive capacity and thus enhance food security in urbanizing deltas.

9. Knowledge sharing and research uptake

Word count: 977

a) Stakeholder mapping and workshop¹ results

Figure 5 presents a stakeholder map. This map was used to identify stakeholders in the two case study areas and to tailor the research design to meet user needs. At the stakeholder workshops¹ participation in the research was discussed.

Farmers in peri-urban zones.

Farmers in peri-urban zones are a diverse group including traditional community farming, modern horticultural enterprises, double income households. etc. Farmers at the workshop¹ expressed their interest to receive water availability information and agreed to participate in virtual communities.

Information owners. Meteorological agencies, water resource committees and research institutes present at the workshops¹, expressed their interest to collaborate and to provide researchers with available data.

Information service providers. ICT companies and NGO's offered their services in developing ICT platforms and apps. This research is interested to contract a SME company on digital communication called Topshare (see www.topshare.com).

Through participation of universities we also aim to contribute to university education (at MSc. level) and to field training.

Information governance authorities. This stakeholder group was represented through the Department of Agricultural Extension at the Bangladesh workshop¹ and we do yet have to establish contact with extension services in Ghana. Research on the governance of information services must address new responsibilities, as much in this field is not yet regulated.

INREF. (see section 9d)

On-going stakeholder engagement

The development of knowledge sharing platforms requires engagement with information owners and information service providers. Local case study coordinators are responsible to maintain contacts on data exchange, ICT development, etc. Engagement with farmers will firstly take place through the virtual community facilities. PhD researchers will physically contact farmers regularly to ask for information needs, experiences with platform functioning, impact assessments, etc. Stakeholders at the workshops expressed their intention to continue collaboration with our research.

b) Capacity development

We see two internal (within the consortium) capacity building needs:

1. Developing research skills with the sandwich PhD candidates;
2. Developing co-production skills with all consortium partners.

Ad 1). Sandwich PhD's will be (co-)supervised by the Wageningen University ESS and PAP Groups, together with the University of Khulna and the University for Development Studies. Sandwich PhD students will become part of the SENSE² and WASS³ Research Schools in the Netherlands. Research Schools require students to develop an individual Training and

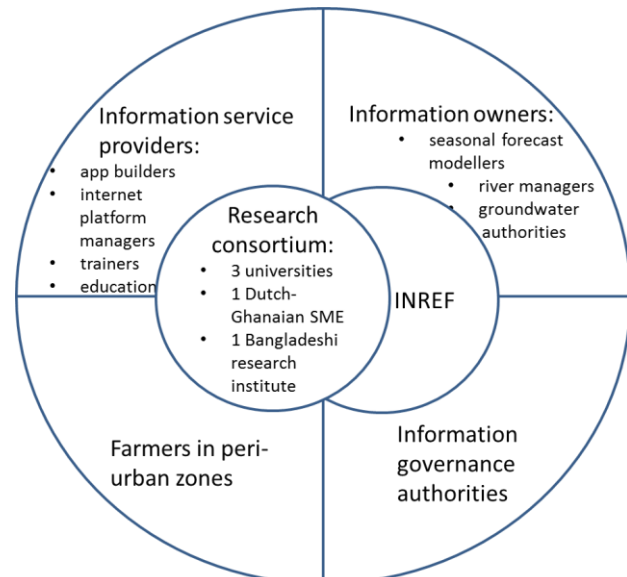


Figure 5: Stakeholder map

¹ See chapter 5

² Research School for Socio-Economic and Natural Sciences of the Environment

³ Wageningen School of Social Sciences

Supervision Plan. This plan is tailor-made for personal development to become an independent researcher. A multitude of trainings and courses is offered as part of this program.

Four participating universities expressed interest in involving master thesis students in the research. Master thesis can be co-supervised.

Ad 2). As this research is multidisciplinary and as the case study areas are arenas for co-production, all participants will be challenged to cross knowledge and experience boundaries. We therefore propose to design project team and project board meetings to:

- alternate locations between three participating countries;
- include field visits in meeting's agendas. Through participation in real life research activities a shared experience and a common understanding will emerge;
- create a website (open to the public) to share intermediate results and discussions;
- facilitate content related reflection.

External capacity

External capacity needs are:

1. Farmers know-how in engaging with ICT technologies
2. National and regional meteorological and water management agencies capacity to manage climate and weather data and information.

Tailored trainings will be developed to address these needs. MDF West Africa will use these trainings for further commercial development of training and capacity building material.

c) Communication

Activity	target group	objectives	means of communication
knowledge sharing platform and virtual community	agricultural sector in peri-urban delta areas in Accra and Khulna	co-production of water information services (see chapter 6)	internet, SMS services, local radio
open access website	potential users of our innovations and results in other deltas	disseminate research and innovation results	internet
scientific papers	scientific community	research results	in peer reviewed journals
advertising for PhD or master thesis positions	academic communities	involve good students	university channels and open advertisement
Professional publications	private sector	upscale the use of waterapps	professional journals

d) Shared knowledge activities

Wageningen University is investing, through its Interdisciplinary Research and Education Fund (INREF) facility in a research called: Responsible life-sciences innovations for development in the digital age: Environmental Virtual Observatories for Connective Action (EVOCA) in crop, water, livestock and disease management.

<http://www.wageningenur.nl/nl/project/Environmental-Virtual-Observatories-for-Connective-Action-Evoca.htm> .

EVOCA's central research question is: How can life-science knowledge, digital technologies and responsible innovation concepts be leveraged in development contexts to build inclusive virtual platforms for environmental information that enable connective action for addressing development challenges in crop, water, health and wildlife management? The Wageningen University ESS and PAP groups and the University for Development Studies are involved in a case study on water and climate in rice cultivation in Northern Ghana. Waterapps will collaborate and create synergy with EVOCA, and will take an essential additional step by connecting information about water availability with relevant stakeholders in peri-urban areas.

BCAS is involved in the “Transforming Climate Knowledge with and for Society (TRACKS)” research. The TRACKS project aims to study how communities in northeast Bangladesh can mobilize high-quality knowledge in support of local climate change adaptation. This experience connect to the citizen science component of this research.

Both BCAS and Wageningen University are involved in the “Hydro-Social Deltas project, financed by Urbanizing Deltas. Synergies on flood related aspects are possible.

Both the University for Development Studies (Ghana) and BCAS (Bangladesh) were involved in the UNEP funded “Building Urban Resilience; Assessing Urban and Peri-urban Agriculture in Tamale, Ghana” study. The approaches to peri-urban agriculture are a basis for our research.

The Wageningen University ESS Group is involved in the European Union 7th Framework “European Provision Of Regional Impacts Assessments on Seasonal and Decadal Timescales” (EUPOREAS) research (see: <http://www.euporias.eu/>). Although the main focus is on Europe this research program does have interest in collaboration with African and Asian countries. Exchanges among researchers and contributions to trainings will be sought.

Stakeholder Consultation Workshop

Two stakeholder workshops the first in Khulna (Bangladesh) on May 31st and June 1st, and the second in Accra on June 30th were held with the following objectives:



Khulna workshop participants

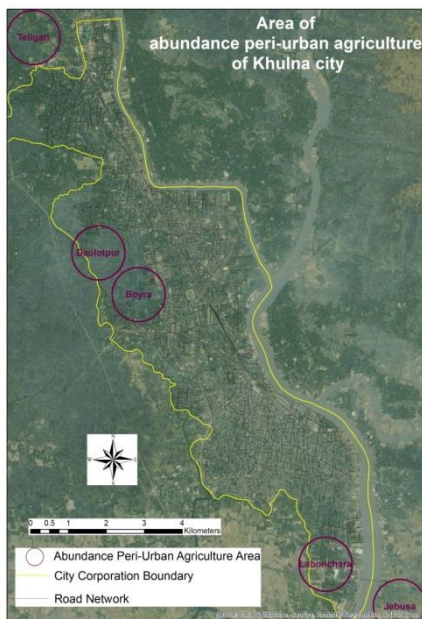
3. To discuss stakeholder analysis results and stakeholder involvement; identify the ways in which stakeholders wanted to be involved in the project, and inform a project communication strategy. inform the social and political context analysis for the issues (who were key actors, what were the power relations between actors)
4. To discuss potential for valorization of project results.

1. To discuss general research objectives, including relevance of the research questions and project focus to local stakeholders from different sectors; provide feedback on the knowledge gaps and research questions that had priority;

2. Rapid appraisal of the peri-urban farming systems, aiming at identification of major vulnerabilities and risks and a first assessment of information needs. Identification of potential for Rabobank's virtual farmer platform;



Group discussions in the Accra workshop. Right farmers group, left in the back ICT companies, left in front government



Map of Khulna, with peri-urban agricultural areas (see red circles). The northern and middle areas produce vegetables, the southern shrimps and aquaculture

Bangladesh workshop report

Primary water uses in the peri-urban areas of Khulna are;

- domestic (drinking, washing, bathing)
- agricultural and aquaculture
- industrial use

Rapid urbanization and climate change impacts are causing water insecurity to the coastal peri-urban communities of Bangladesh. Water availability, quality and access are adversely affected by urbanization and industrialization in Khulna peri-urban area which is leading to competition and conflict over water. Most farmers households are suffering from food crisis whereas they were food surplus region. The key (peri-urban agriculture related) water problems in the Khulna peri-urban area and their drivers and causes are;

1. Water Logging and flooding – The principal reasons of water logging are land reclamation works, impeding drainage and river flows and sea level rise.
2. Salinity intrusion both in surface and ground water are affecting drinking water and water for agriculture. Sea level rise and less fresh water discharge from upstream are salinity intrusion in the surface and ground water.

The participants wanted to be kept informed about the Waterapps project. It was concluded that annual face to face stakeholder meetings were desirable, as well as more frequent updates via a project newsletter - and updates on the respective websites of the consortium partners. As there is a close community within khulna of organizations and institutes dealing



Khulna, harvesting vegetables

with peri-urban agriculture project stakeholders are already in frequent communication with each other, and news also passes informally through these channels.

Ghana workshop report

This workshop brought stakeholders with a large diversity of backgrounds together: from small scale farmers to commercial farming, to ICT and consultant companies, to governmental services and universities. This diversity facilitated a very rich dialogue.

Main conclusions are:

- There is a need for seasonal forecasting of rainfall and irrigation water (from rivers and dams, groundwater and urban waste water) in the Greater Accra Region peri-urban agricultural sector, because there is a strong sense among farmers that rainfall becomes less predictable and farmers cannot rely on experiential knowledge alone anymore.
- There is room for improvement of dissemination of information towards farmers. The current information chain is long with many segments and information may arrive too late or not at all. Extension services are for many reasons not reaching the farmers with relevant information.
- Farmers expressed their willingness to collaborate with this research by providing access to their fields and by testing information services platforms.
- Farmers do have potential to access to internet and ICT services. But many lack the know-how to use these. The project should take care to use appropriate technologies. An example is the use of community radio (also known as 'fm' or rural radio and often owned and managed by NGO's). These use local languages and are very popular among the rural population. These radios may be used as dissemination and discussion channels, because an important ingredient of these radio programs are discussions among listeners.
- Ghanaian meteorological and water management governmental institutes possess data on seasonal forecasts. But these data are fragmented. There are data gaps and output of different institutes is not always integrated. The director of G-Met and the Water Resource Commission representative both promised free access to data and expressed their interest to collaborate with this research.
- There is an interest to collaborate with Bangladeshi parties (south – south collaboration)
- Sustainability of the research is a point of discussion:
 - The platform itself might be taken over by a commercial party. Payment by farmers is probably not a viable option (although some farmer present at the workshop expressed a willingness to pay), but insurance companies might be willing to pay for data. Ghana is developing insurance services to farmers
 - The ICT platform as we see it now, is probably outdated at the end of this research. So maybe a better guarantee for sustainability is training and capacity building of farmers (to enhance their capacity to find relevant information) and information providers (to close data gaps and to integrate different data sources)



Accra property development meets small farmers plots