Deployment of Open Data Kit for Information Management for Various Engineering Projects In Rural, Indonesia

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***Abstract*—Open data kit was used in an Engineering context as a data collection, storage and management tool for diverse data types from irrigation channels, weirs, saturated rice paddies and ephemeral stream catchments in the *Eastern Indonesian province of Nusa Tenggara Timur.* In the islands of West Timor and Flores, information was primarily used to report maintenance issues in the weir, primary, secondary, tertiary and quaternary channels. In Sumba, data was recorded for flow velocity and elevation in saturated zones and sedimentation in an ephemeral stream. Information regarding physical characteristics from groundwater wells was also collected to assess drinking water quality. Smart phone data input forms were developed progressively using Open data kit Build, according to the specific needs of each research project. It was found to be a very user-friendly and effective tool to use in the Engineering context. The features of Open data kit Build allowed us to modify the various forms in remote locations. Developing multiple choice input focused forms made data collection easier for farmers and local government workers. It virtually eliminated the need for hardcopy data, and allowed for versatility with respect to the nature of the multidisciplinary research.**

***IndexTerms*: Open data kit, irrigation channels, saturated zone, ephemeral stream, groundwater.**

I. INTRODUCTION

Open Data Kit (ODK) is a free, open-source set of tools developed at the University of Washington's Department of Computer Science & Engineering. It assists in building application specific information services for use in resource constrained environments [1] and comprises of ODK Collect, Aggregate, and Build [2]. ODK is implemented through the use of hand-held Android Smart Phones (ASPs), and is known to reduce survey times and eliminates the need of paper surveys [3]. The application of mobile phones to data collection is not a new concept for example,open platform applications such as Frontline SMS and Rapid SMS are available.However, these platforms are useful for simple text and short form data strings. ODK is suitable for more complex data including photographs, GPS data and voice recording[3].

ODK has potential for use by a variety of data users including government workers, agricultural extension officers, teachers, crisis workers, and clinicians [2, 4]. Most previous applications of these open platform tools are focused on collecting health data in under-serviced communities. In a recent study by Tom-Aba et al.[5], ODK was used as an Ebola outbreak response measure in Nigeria to follow-up on reported cases, and the identification, investigation and management of Ebola cases, which allowed for strategic planning during the response. Successful application and an enormous improvement was noted in reporting of follow-up contacts after ODK was implemented.

Although many successful deployments of ODK involve health assessment and management[5, 6], there is potential to apply this technology to sustainable engineering applications in subsistence farming areas of underserved communities. The focus of this study is to highlight the development and deployment of ODK for various Engineering research projects which we carried out in the *eastern Indonesian province of Nusa Tenggara Timur (NTT)*. ODK forms were built to report and record data for issues such as maintenance in irrigation channels and weirs, flooded rice paddies, sedimentation in ephemeral streams and physiochemical parameters in groundwater (GW) quality. The focus of this study is to identify issues for each of the Engineering contexts and develop and deploy ODK forms. Also, there was a focus on performing detailed analysis of the maintenance issues in irrigation channels and weirs in the *eastern Indonesianprovince,*NTT.

II. STUDY SITE

The study started as a need to deploy*an open-source field data collection and information management tool for use in irrigated farming areas in the eastern Indonesian province of NTT, which consists of the major islands of Sumba, West Timor*

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and Flores. The province has a monsoonal wet-dry tropical climate, and water resources are limited, with high inter-annual variability. Some (80%) of the people live in rural areas and rely on agriculture for their livelihoods [7] and it has a high proportion of food-insecure households [8, 9]. Weirs and irrigated rice fields were constructed in the lower reaches of the major catchments of NTT province with considerable support from the Japanese Small Scale Irrigation Management Project. However, paddy production remained low[10], with a typical irrigated rice productivity of 1-1.5 t/ha in NTT compared with 6-8 t/ha in Western Indonesia [11].

To address these concerns, field studies occurred in irrigated farms on Sumba in May 2015 and on Flores and West Timor in November 2015. It was found that irrigation infrastructure in some farming areas were in a critical state of disrepair reducing food security for local people in these irrigation developments. Furthermore, problems of water and food security were chronic and threatened lives and livelihoods[11]. To collect representative data, a field visit was made to West Timor to collect maintenance data and to Sumba for flooding, sedimentation and GW data, in June and July, 2016, respectively.

III. IRRIGATION RELATED ISSUES

There were multiple factors contributing to low productivity of irrigated rice in *NTT province*. Delivery of irrigation water is generally inequitable and unreliable because of problems with both the physical function of infrastructure and the governance and management of water delivery [12]. The islands of Indonesia have some of the highest rates of sediment transport in the world [13]. Sedimentation in irrigation channels severely restricted irrigation water delivery. The required on-going maintenance due to sediment transport and deposition in irrigation infrastructure was often lacking.

The delivery of irrigation water was controlled by officers from four levels of government (national, provincial, district and village).In many cases management was ineffective due to lack of coordination. Initial inspections of the irrigation channel infrastructure indicated that long-term lack of coordinated maintenance of the system had critically affected the ability of irrigation infrastructure to function well enough to provide food security to its dependent communities [9]. The effect of this lack of maintenance has been exacerbated by Engineering design flaws, such as ephemeral stream management, and poor drainage and erosion management. Farmers' focus group discussions in villages in Sumba indicated that there was no consolidated database of maintenance requirements that can be used to plan a regular maintenance programme and the associated budget. In some areas degradation of the system was such that no irrigation water reached paddy fields and farmers were dependent on natural flooding[11]. Hence, it became a matter of critical importance that a database be established as a basis for planning maintenance schedules and providing data regarding poor drainage, ephemeral streams, sedimentation and other issues.

The challenge was to work effectively with local stakeholders in Indonesia to develop appropriate tools to inform improved maintenance and management of the irrigation system. There are some significant and pressing maintenance issues but there are also many non-point source small issues that if left will only exacerbate the malfunctioning nature of the system. Before an effective programme of maintenance can be put in place, planners and managers needed data.

IV. GROUNDWATER QUALITY ISSUES

The field study also investigated poor drinking water quality and sanitation in irrigated areas through household interviews. These showed that drinking water was almost universally sourced from wells for which water quality was largely untested. Water for other household needs (washing clothes, toilet and sometimes personal hygiene) and livestock (cows, pigs, poultry, goats, horses) was sourced from irrigation channels[11]. Groundwater is a reliable source of water for drinking, household chores and irrigation in many parts of the world [14, 15] but may be an under-utilized resource in NTT province as observed during the field trips. It is unknown if an inventory of GW wells exists or how the density of wells compares with other areas. The GW resource in Sumba is not well defined with the most recent hydrogeological map being constructed in 1965 [16]. Hence, this paper also focuses on generating user specific ASP data input ODK forms for storage of all physiochemical parameters measured in field, which can be used by various stakeholders.

V. ODK DEVELOPMENT AND DEPLOYMENT

A significant challenge in data collection and maintenance planning is coordinating among the different levels of government. To address the shortage of required information, a maintenance regime was recommended to be established to improve functioning of the irrigation system. With a well-managed system and operational gates at the weirs and throughout channels systems, water flow can be controlled during the wet season allowing the channel system to cope with large rainfall events. Some major channel repair works and regular maintenance will ensure water flows to all parts of the system so that small-holder farmers receive enough water to grow sufficient crops at the end of the channel system so the community - "hungry season" is ameliorated[17] .Table 1 shows the timeline and projects and their respective ODK form development.

VI. RESULTS AND DISCUSSION

A. Irrigation Maintenance

This was a large data collection exercise that was of critical importance to the irrigated areas of Sumba, Flores and West Timor. It entailed the collation of an inventory of channel damage, channel sedimentation and saturated irrigation sites, and an analysis of those processes by which sediment enters the irrigation channels. To assess the data from the server, *.kml* files were downloaded for inspection in Google Earth or ArcGIS.

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Table I: ODK Development For Various Engineering Projects

Time-line	Location	Projects	ODK development
05/ 2015	Sumba	- Irrigation, maintenance, - GW quality issue	Need for a consolidated database of maintenance requirements needs to be established, hence ODK was selected.
11/ 2015	Flores &West Timor	- Irrigation, maintenance	- Compiled an inventory of primary and secondary irrigation channels, sedimentation and channel damage issues in ODK; very initial trials were run. - Established a database framework that can be used by local managers as an information system to develop repair programs of work.
06/ 2016	West Timor - Linamnutu	Irrigation maintenance	Developed and deployed the final ODK forms according to priority, channel and issue type etc.
07/ 2016	Sumba	- Saturated zone - Ephemeral stream - GW quality issue	ODK forms were built according to each project specification and deployed

Figure 1 shows locations of data collected in the Noalmina River catchment inSouth Central West Timor, using the trial form with all the maintenance issues. Figure 2 shows the results of the maintenance issues using the final ODK form, which were classified into categories of sedimentation, channel damage, vegetation, human related causes etc and deployed in Linamnutu village, West Timor. The final ODK form allowed choice between irrigation block, channel level, the ability to post a photo for each maintenance issue and to describe the issue and cause in detail. Figure 3 shows the type of data available for each point location on the Google Earth maps.

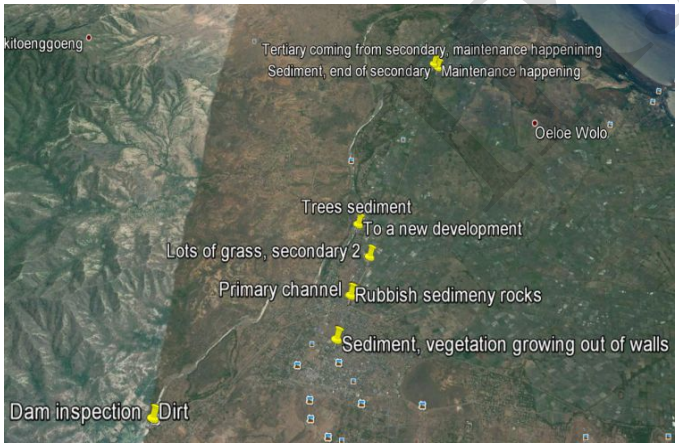
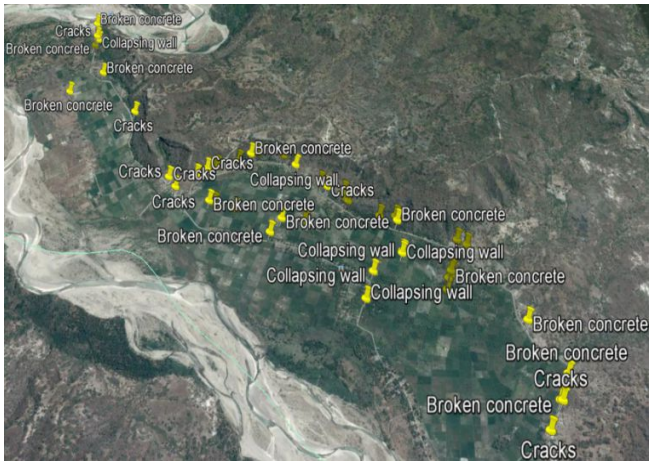
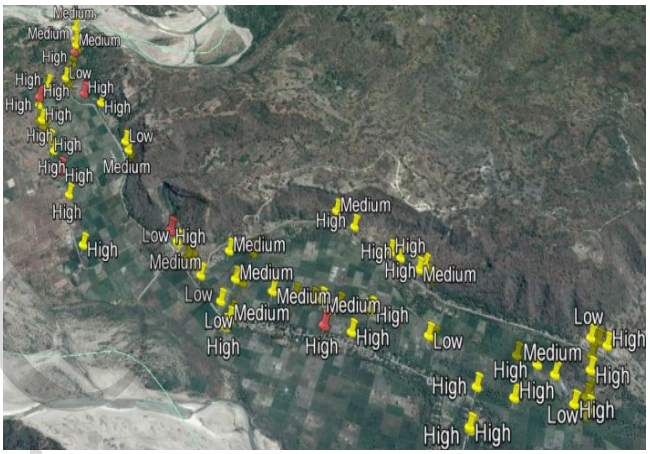


Fig. 1: Irrigation maintenance issues in Aesesa catchment, Flores, using the trial ODK form



(a)



(b)

Fig. 2: Classified irrigation maintenance issues (a) channel damage and (b) maintenance priority in Linamnutu, West Timor, using final ODK form

The development of the forms began in the Aesesa catchment, where the main weir was built in an area of high sediment transport and deposition.With respect to the ODK form development and deployment, the trial form prompted the user to type full text descriptions which was time consuming. The issues were not categorized at that stage, as we did not know which issues were most prominent. Hence all data were displayed in one map as shown in Fig. 1. The visualization of field data did not facilitate interpretation. Consequently, the form was iteratively modified and tested and the final form was deployed to collect data, during field work in Linamnutu, West Timor. The form featured multiple choice rather than full text entries, which reduced the time required for the end users to enter data. Less typing was involved and users just had to select the option which was applicable to the maintenance issue at that particular location. The last tab also provided an option to type in a description of the issue in more detail. This classification of maintenance issues, based on initial ground truthing allowed for the maintenance issue to then beprioritized based on its likely impact.

Sediment - boulder



null

meta:instanceID	uuid:337fa6a8-1ad9-438b-ac98-7cbbf4e48545
Camera_setting	
Village_name	Linamnutu
Site_record	D3MN01
Date	Wed Jun 29 00:00:00 UTC 2016
GPS:Latitude	-10.0536909300
GPS:Longitude	124.1920806500
GPS:Altitude	66.0000000000
GPS:Accuracy	3.0000000000
Irrigation_bock_number	Block 4
Channel_level	Secondary Tertiary
Select_most_significant_issues	
Sediment	Sediment - boulder
Photograph_1_sediment	View
Channel_damage	Other - describe in free text below
Photograph_2_channel_damage	View
Vegetation	Vegetation - dead (eg. tree fall)
Photograph_3_vegetation	View
Human_cause	Rubbish
Description_issue_cause	No walls on tertiary
Maintenance_priority	High

Fig. 3: ODK download showing the location of irrigation system data collected using ODK tools on an ASP

The application of this suite of tools to data collection in remote locations across the islands was not a difficult task. The establishment of the ODK servers was completed before the field trip. This was the most challenging part ofthe ODK application. Establishing the servers was exacerbated by the slow rate of download file transfer on the available network.

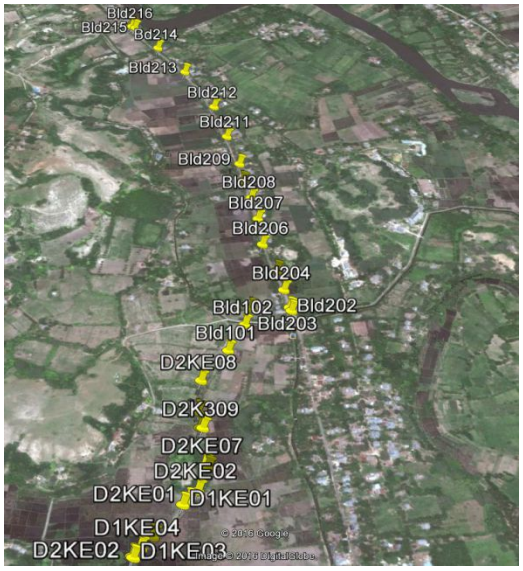
However, after the first server was in place, creation of the next two was simple. In the field, personal ASPs were used with quality ranging from cheap and medium-quality to quite expensive high-technology devices. Different qualities of ASPs were used with quality ranging from cheap and medium-quality to quite expensive high-technology devices. Different quality ASPs had an effect on the speed of obtaining GPS locations and, on several occasions, the accuracy of the GPS location.

However, it was found by downloading a GPS satellite application and using this for the GPS location feed and to update satellite data, speed and accuracy were improved. Another improvement on collecting GPS data was to use an android application to Bluetooth GPS data from a non-android mobile phone of high quality and with more accurate GPS capability.

By using local network SIM cards we were able to obtain relatively inexpensive data (24,990 IDR/GB) for uploading but this needs to be further investigated. Downloading data from the servers for interrogation in various formats is simple: the *.csv* file format is useful for creating report tables with locations, descriptions and photograph URLs.

B. Saturated Area

In the saturated area of KelurahanLambanapu, measurements such as elevation, water depth, flow velocity etc. were measured and recorded on the specifically designed ODK form. Various measurements across the Lambanapucatchment were recorded as shown in Fig. 4.



(a)



meta:instanceID	uuid:456eaf05-8124-465a-a20c-dedae2707023
Site	Lambanapu saturated zone drain
Site_record	D2KE08
Date	Wed Jul 13 00:00:00 UTC 2016
Picture	View
Hydrodynamic_data	
measurement_location	Main drain
flow_direction	Northeast
Elevation_location_right_wall:Latitude	-9.7009603800
Elevation_location_right_wall:Longitude	120.2781205600
Elevation_location_right_wall:Altitude	37.0000000000
Elevation_location_right_wall:Accuracy	5.0000000000
Right_GNNS_elevation	
Elevation_location_left_wall:Latitude	-9.7009457800
Elevation_location_left_wall:Longitude	120.2781251700
Elevation_location_left_wall:Altitude	38.0000000000
Elevation_location_left_wall:Accuracy	5.0000000000
Left_GNNS_elevation	
Water_depth_1	0.4810000000
Water_depth_2	0.5300000000
Water_depth_3	0.5400000000
Water_depth_4	0.5000000000
Channel_depth	2.3600000000
Comments_previous_measurements	The 1st measurement for sediment depth is always R bank
Channel_width	1.3550000000
water_flow_right_velocity	0.2000000000
Flow_rate_centre_of_channel	0.3000000000
water_flow_left_velocity	0.3000000000
Depth_flow_measurement	30
Comment_velocity_measurement_location	Depth of measurement 30cm

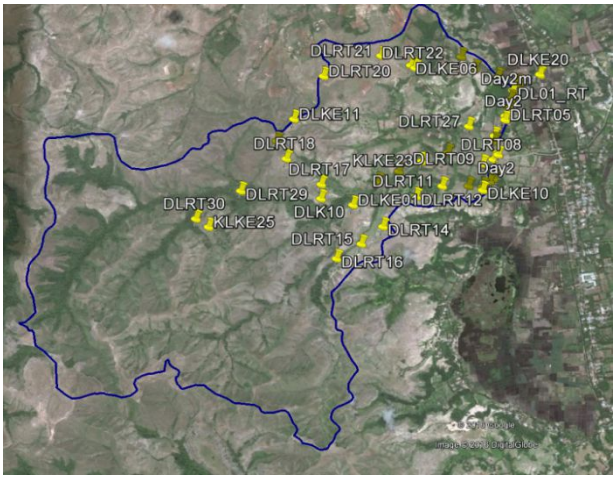
(b)

Fig. 4: (a) Locations of measurement across saturated zone in Lambanapu, Sumba and (b) Outline of the data collected

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C. Ephemeral Stream

A large ephemeral stream catchment in the Lambanapu district, measurements such as bank and channel location and dimensions were taken as shown in Fig. 5. Measurements were taken across the stream catchment and recorded in the ODK form specifically designed for that purpose. Two adjustments were made to the catchment mapping form and a "photograph" form was developed for quick data entry where less details was required.



(a)



meta:instanceID	uuid:a7eccdf8-1aca-4ccc-85c8-f59aa9cd02ea
Low_camera_resolution	
record_ID	DLRT05
date	Wed Jul 13 00:00:00 UTC 2016
GPS_location:Latitude	-9.6973736900
GPS_location:Longitude	120.2770657300
GPS_location:Altitude	60.0000000000
GPS_location:Accuracy	5.0000000000
soil_sample_collected	No
Soil_sample_ID	Nil_ gravel and cobble present
photograph_sample	View
comments_soil_sample	
terrain_slope_percent	
Select_veg_type	Understory
Vegetation_type	Lantana
photograph_vegetation	View
vegetation_comments	
channel_measurements	
GPS_right_bank_channel:Latitude	-9.6973400000
GPS_right_bank_channel:Longitude	120.2770739800
GPS_right_bank_channel:Altitude	59.0000000000
GPS_right_bank_channel:Accuracy	4.0000000000
GPS_left_bank_channel:Latitude	-9.6973278800
GPS_left_bank_channel:Longitude	120.2770735100
GPS_left_bank_channel:Altitude	56.0000000000
GPS_left_bank_channel:Accuracy	5.0000000000
GPS_centre_channel:Latitude	-9.6973258000
GPS_centre_channel:Longitude	120.2770697000
GPS_centre_channel:Altitude	57.0000000000
GPS_centre_channel:Accuracy	5.0000000000
channel_width	9.5400000000
channel_depth	1890
channel_photograph	View
Comments_channel	Channel depth in mm and in middle of flow way

(b)

Fig. 5: (a) Locations of measurement across the ephermeral stream in Lambanapu and (b) Outline of the data collected

D. Groundwater Quality

Open wells in Lambanapu and MauliruKelurahanin Sumba were tested for GW quality. The villagers were interviewed on the age of the well, maintenance issues, diseases related to well water quality etc. The well was purged [18] and physiochemical parameters were measured using a multiparameter meter for various locations in the GW ODK form(Fig. 6).



(a)



meta:instanceID	uuid:eee51813-ccd6-4084-8113-3ac57be90e40
Village	Kelurahan Mauliru
Name	DEKES9
Date	Sun Jul 17 00:00:00 UTC 2016
Location:Latitude	-9.6757501700
Location:Longitude	120.2944124300
Location:Altitude	60.0000000000
Location:Accuracy	5.0000000000
Well	Very deep concrete collar and lined. Depth to WS = 8.01 m, 12m
Photo	View
maintenance	
Picture2	View
pH	7.21
EC	713 uS/cm
Temperature	30.1 °C
Turbidity	ORP: 154.8 mV
DO	73.6% Sat; 5.48 mg/L
TDS	461 mg/L
Salinity	0.30 PSU
SSG	0
Pressure	1011 mb

(b)

Fig. 6: (a) Locations for GW measurement across Lambanapu and Mauliru districts and (b) Outline of the data collected

VII. RECOMMENDATIONS

By working with Government and community stakeholders, it is recommended that a framework be developed for implementing a maintenance programme in the studied areas. This will involve clearly defining who has responsibility for which parts of the irrigation system, for example, who is responsible for maintaining the primary, secondary, tertiary and

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quaternary channels. Upon discussions with farmers, the impression was given that Central Government was responsible for the primary and secondary channels, District Government is responsible for the tertiary channel and the villages are responsible for quaternary channels. Also, a programme should be designed in future to work with NTT communities to implement ODK data collection techniques and develop a sample maintenance programme to repair issues identified during data collection exercises. Ideally, data collection would be coordinated with the existing work plans of the stakeholder groups.

It is recommended that further studies work with Indonesian partners to advance this technology in an original way by applying it for the first time to sustainable engineering applications in subsistence farming areas of eastern Indonesia. This study showed that ODK can be used to collect data related to irrigation channel water flow and quality, irrigation channel damage, and environmental characteristics (vegetation, soils, geology, erosion). The logistics of this project will require training of local people to undertake field work and data recording in future. Establishment of a maintenance programme will require Government cooperation and coordination as well as funded positions to establish continuity of survey and maintenance teams.

VIII. CONCLUSIONS

As a result of this intensive field study in Sumba, Flores and West Timor over a period of one year, an enhanced understanding of the irrigation and water quality issues has been achieved. We have been successful in developing various easy and user-friendly ODK forms for issues related to irrigation maintenance, saturated areas, ephemeral streams and groundwater drinking quality. We also managed to determine and classify important maintenance issues through a progressive study across the islands. ODK has proven to be a versatile tool for use in these Engineering contexts with further potential to collect other types of data, such as some types of interview data.

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