Integrated Breeding Platform

Today's tools
for tomorrow's crops

Background

Growth in scientific knowledge and innovation and advances in information and communication technology (ICT) over the past two decades have jointly provided new tools, avenues and resources to address food security. The global agricultural research agenda must take advantage of this progress to enhance the agricultural knowledge base and provide innovative solutions.

Biological sciences are now extremely 'data-rich'. This quantitative nature of modern biology demands closer collaboration between biologists and informaticians, as well as strong partnerships between researchers in both developing and developed countries, across sectors and disciplines. The concurrent revolutions in genomics, molecular biology and information technology offer unprecedented opportunities to enhance breeding programmes. Consequently, molecular characterisation, accurate phenotyping, analytical tools and overarching information systems must be integrated with breeding workflows combining pedigree, phenotypic, genotypic and adaptation data for better predictions on the performance of different genotypes across various environments.

However, although molecular breeding approaches have been readily adopted by and proved to be of great benefit to the private sector, they have had limited impact in the public sector and in small private enterprises. The reasons for this vary, but include: lack of personnel, inadequate high-throughput genotyping capacity, unreliable phenotyping practices and protocols, inadequate infrastructure, poor information management systems backed by inadequate analytical tools, and generally insufficient resources. These have slowed development of new cultivars and compromised food security.

The development of the Integrated Breeding Platform[1] is intended to help overcome these bottlenecks. To achieve these objectives, GCP allocated about USD 22 million to the IBP initiative over five years (July 2009 to 2014), with financial support primarily from the Bill & Melinda Gates Foundation with additional funds from the European Commission, the UK Department for International Development (DFID), the CGIAR Consortium, and the Swiss Agency for Development and Cooperation (SDC).

The Integrated Breeding Platform – An Introduction

The Integrated Breeding Platform (IBP) is a multi-partner initiative of CGIAR Centres, various universities, national programmes and private sector partners coordinated by GCP. It is a vehicle to promote access to modern methods and technologies to empower breeders in developing countries to adopt and apply molecular breeding approaches. It not only permits broad access to knowledge and information, but also the proactive distribution of crop genetic stocks and breeding materials; molecular, genomics and informatics technologies and information; cost-effective high-throughput laboratory services; technical and professional support; and, capacity-building programmes, including training courses and learning resources.

Moving from manual to electronic data capture and trial management represents a major breakthrough in increasing data quality and operational efficiency of breeding programs in developing countries, contributing to the 'digital revolution' in agriculture. Standardized and well-documented data will also facilitate data comparison, exchange and meta-analysis across projects and eventually crops.

In view of this, the centrepiece of the IBP is the Breeding Management System – a consolidated suite of software applications and crop databases specifically designed to help breeders to manage the logistics, data storage, statistical analysis and decision-making for integrated plant breeding. The BMS comprises

[1] See website at http://www.integratedbreeding.net

of mutually compatible interconnected data capture and quality assurance tools, comprehensive analytical toolboxes, and advanced decision-support tools, ensuring a seamless flow of information.

Though primarily targeting public-sector crop breeders in developing nations, IBP will also be available to crop breeders in developed countries and the private sector worldwide. It is being developed in collaboration with 14 pioneer 'user cases' – breeding projects for eight crops in 32 developing countries in Africa and Asia.

IBP Users

The primary target group of the IBP comprises:

- NARS partners wanting to enhance the effectiveness of their breeding programmes by **integrating** molecular methods
- All interested CGIAR breeding programmes and networks
- SMEs working in developing countries, without the in-house capacity to build a breeding workflow system

The secondary target group is basically anyone else running breeding activities, both the public and the private sectors

Although the IBP initiative has a clear humanitarian purpose and has been developed with multilateral public funds, meaning it is an international public good, the provision of such a complex pipeline of tools and services without concomitant technical support, training, and professional support would lead to either poor or no adoption. To offer a free product without the corresponding support would not meet the needs of the target groups. It is therefore absolutely essential for the Breeding Management System to be offered to users as a consolidated package of tools and technical support with modular training and professional support.

How comprehensive this package is will be determined by the needs and resources of each user. A preliminary evaluation indicated three possible 'user/client tiers':

a. Tier 1: Free for users in the public sector from developing countries, including CGIAR
b. Tier 2: Major discount for users based in the public sectors from developed countries (North America, Europe, Australia, New Zealand and Japan)
c. Tier 3: Full price for private companies (modular based on net income)

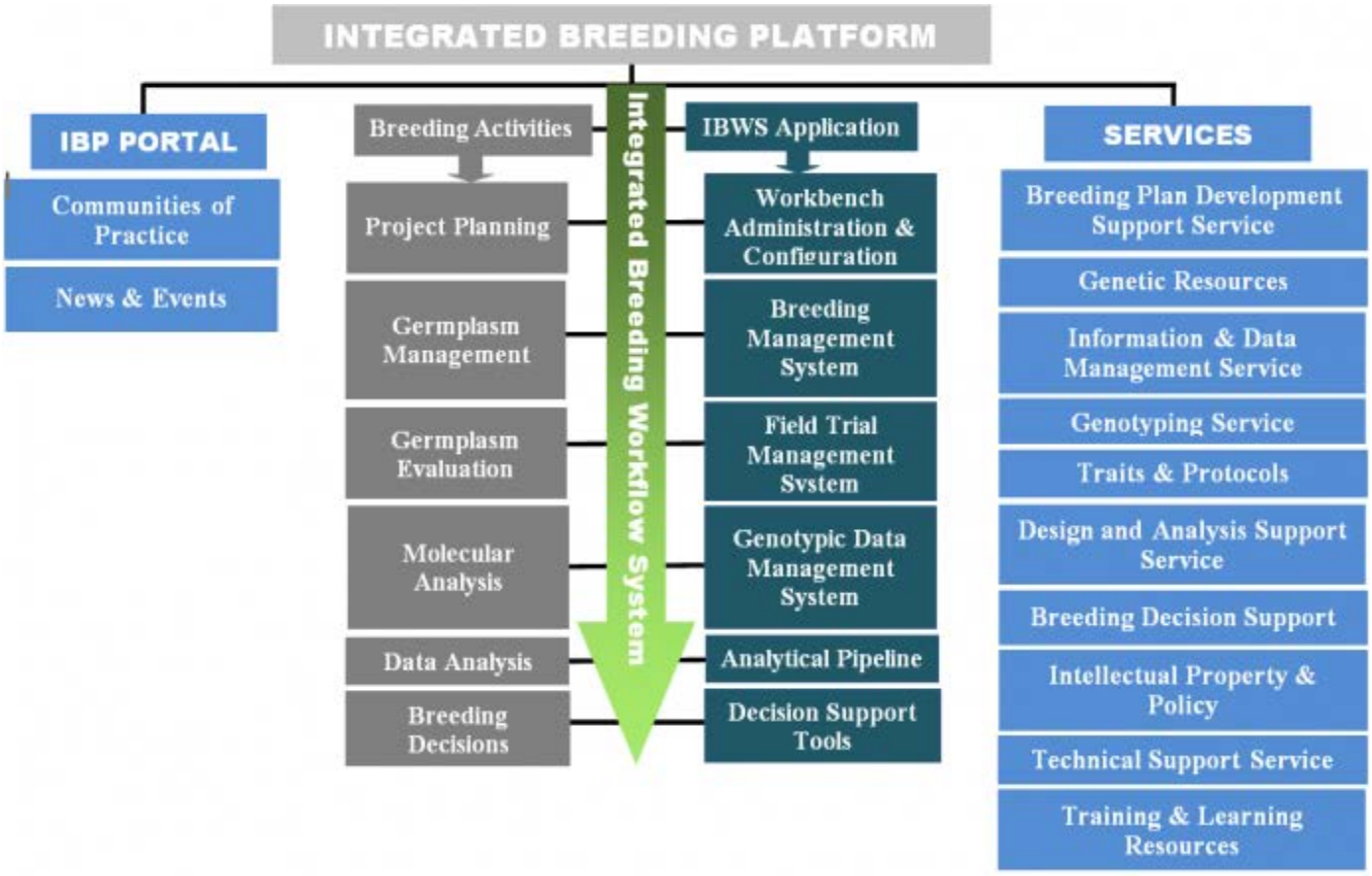
The Platform at a Glance

The IBP has three broad components: a web-based portal, an open-source information & data management system comprising of the modular Breeding Management System (BMS), and Breeding and Support Services offering technical, professional and capacity-building support to users of the platform.

The IBP Portal

The portal is the online gateway through which users access and download breeding informatics tools, procure services, access teaching & learning resources, and interact with their peers in various communities of practice and professional networks. The portal's helpdesks facilitate its use and ensure access for users who cannot efficiently use the web interface, by providing the elements they need via email, CD and other offline media.

The Platform aims to build vibrant crop-based communities of practice to facilitate mutually beneficial sharing of experiences, information, tools, best practices and improved varieties; while promoting application-oriented and more collaborative research approaches. It provides community-building and interaction facilities for peer-to-peer support and problem solving.



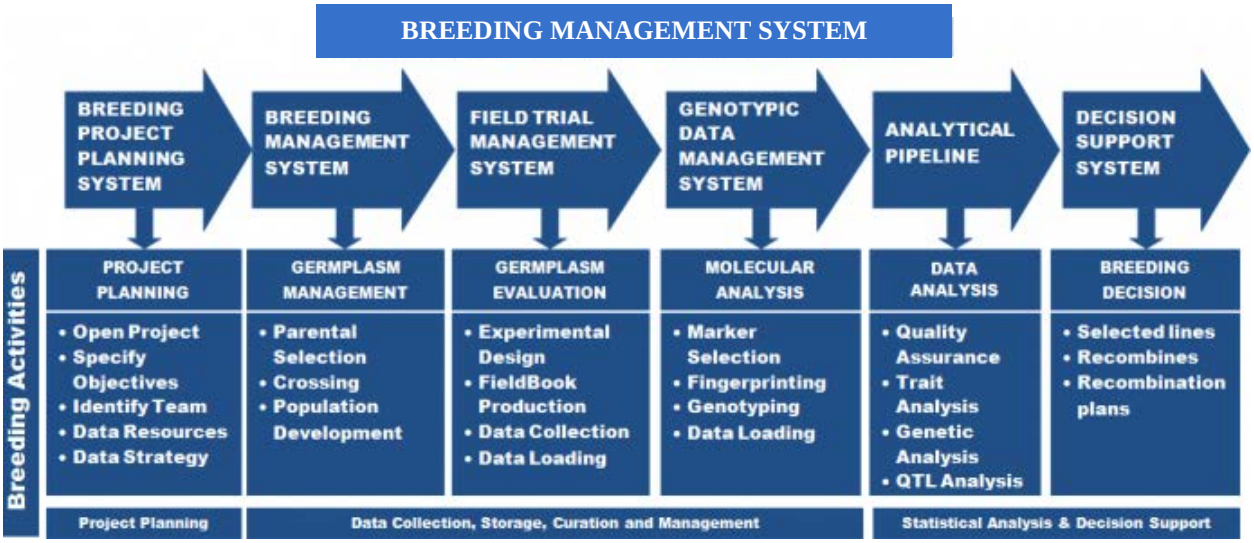
IBP staff and designated community members provide technical backstopping and other support to enable registered community members to make blog posts, join various discussion forums, announce their variety releases, access and disseminate publications, and enjoy technical support by posting queries on specific topics.

The IBP Information & Data Management System

The centre-piece of the IBP is the Breeding Management System – a consolidated suite of software applications and crop databases specifically designed to help breeders to manage the logistics, data storage, statistical analysis and decision-making for integrated plant breeding. The BMS comprises of mutually compatible interconnected data capture and quality assurance tools, comprehensive analytical toolboxes, and advanced decision-support tools, ensuring a seamless flow of information.

Obtaining the BMS: Users can download and install the BMS from the Integrated Breeding Platform web portal, obtaining everything needed to immediately start using the System. Users can also obtain the BMS on DVD. The BMS applications are largely open-source, meaning they can be freely used and modified. However, because they are complex, they are packaged together with customised training and technical support, for which fees may be charged in the future.

Support for conventional and marker-assisted breeding: The BMS is designed to help breeders managing their day-to-day breeding activities in a very user-friendly and efficient way. It supports both traditional (conventional) breeding and modern marker-assisted breeding approaches. It provides step-by-step guidance to users, streamed through four breeding workflows: conventional breeding, marker-assisted selection, marker-assisted recurrent selection and marker-assisted back-crossing. Genome-wide selection will be added in the future.



Detailed databases: The BMS provides access to crop breeding databases with valuable phenotypic, genotypic and pedigree data, including breeder-customised crop ontology and trait dictionaries, and molecular marker information. Links to third-party resources provide additional information.

Tools for all projects and project stages: The BMS provides purpose-built informatics tools for all stages of the crop breeding process**.** These tools support data management, analysis and decision support, and come with user manuals and tutorials. The tools are tailored to support all breeding projects, from the simplest conventional breeding scheme to the most complex marker assisted recurrent selection project. The IBP also provides convenient access to selected third-party tools.

Project planning: The project planning application in the System helps breeders plan and manage projects (ranging from defining project sites to identifying the key skills that team members need).

Data management: Tools in the BMS data collection and management applications help breeders *manage pedigree and breeding information* (from tracking germplasm samples to managing seed inventories and nurseries); *manage trial and field data* (by creating electronic field books and using tools that make it easier to capture information in databases); and, *manage genotypic data* (for marker selection, diversity analysis, etc)

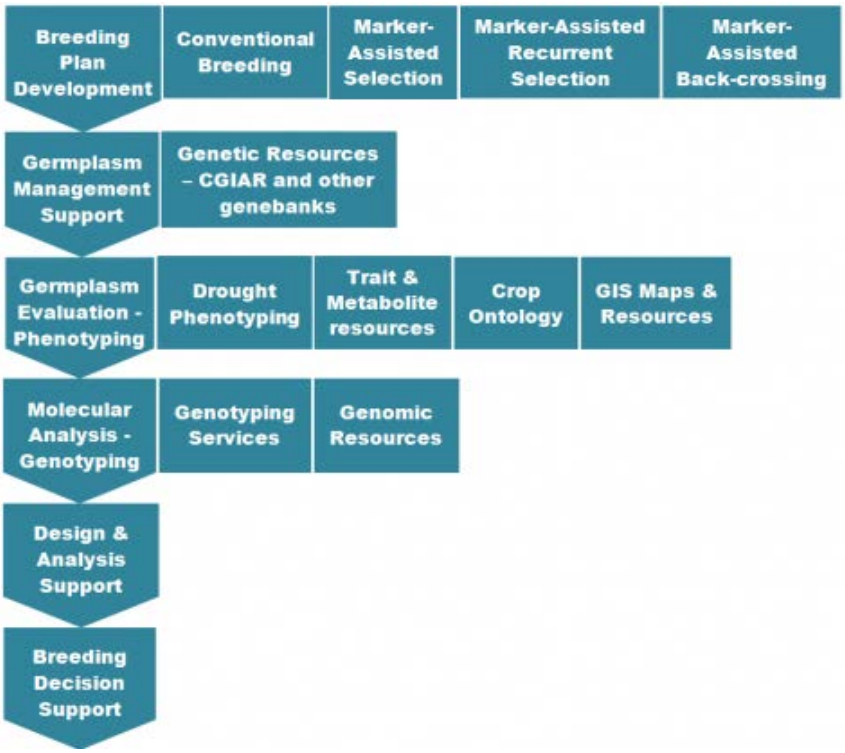
Analysis and decision support: The Analytical Pipeline of the BMS gives breeders the *statistical analysis tools* that they need to analyse the data that they generate in a breeding or evaluation experiment Breeders can use sophisticated statistical methods to assess progenies and make selections for the next phase of development for the entire spectrum from conventional to advanced molecular breeding. The *breeding decision-support tools* help breeders make quick informed decisions on what material to take forward to the next generation; what plants to cross; what plants to keep, and which

ones to discard. These tools handle both simple biparental populations as well as complex multiparental populations.

Technical and professional support: Comprehensive support and capacity building are part of the BMS package. Efforts are underway to set up regional hubs to optimise this support by bringing it closer to users. Within the BMS itself, breeders are shown how to access the different project management, data management, statistical analysis and decision-support tools at each stage of their projects. The BMS guides breeders on when and where to use tools and working protocols – from setting up their experiments to deciding which crosses to make based on the data collected. As a result, even inexperienced breeders using the BMS can easily plan and proficiently apply internationally recognised modern techniques.

Plant Breeding Services

The Integrated Breeding Platform provides access to services to facilitate the implementation of various stages of a breeding programme. Through the Platform, users can obtain services at concessionary fees, including quality high through-put genotyping and sequencing. Other services are provided in-house, to help with breeding plan development, experiment design, information & data management, data analysis, and integrated breeding in general. Platform staff also answer queries posted on the blogs and forums in the crop community pages.



Capacity Development

The Integrated Breeding Platform provides capacity building interventions designed to promote the adoption and efficacious use of modern integrated breeding approaches to cost-effectively hasten the development sand release of improved crop varieties that are more productive and more resilient.

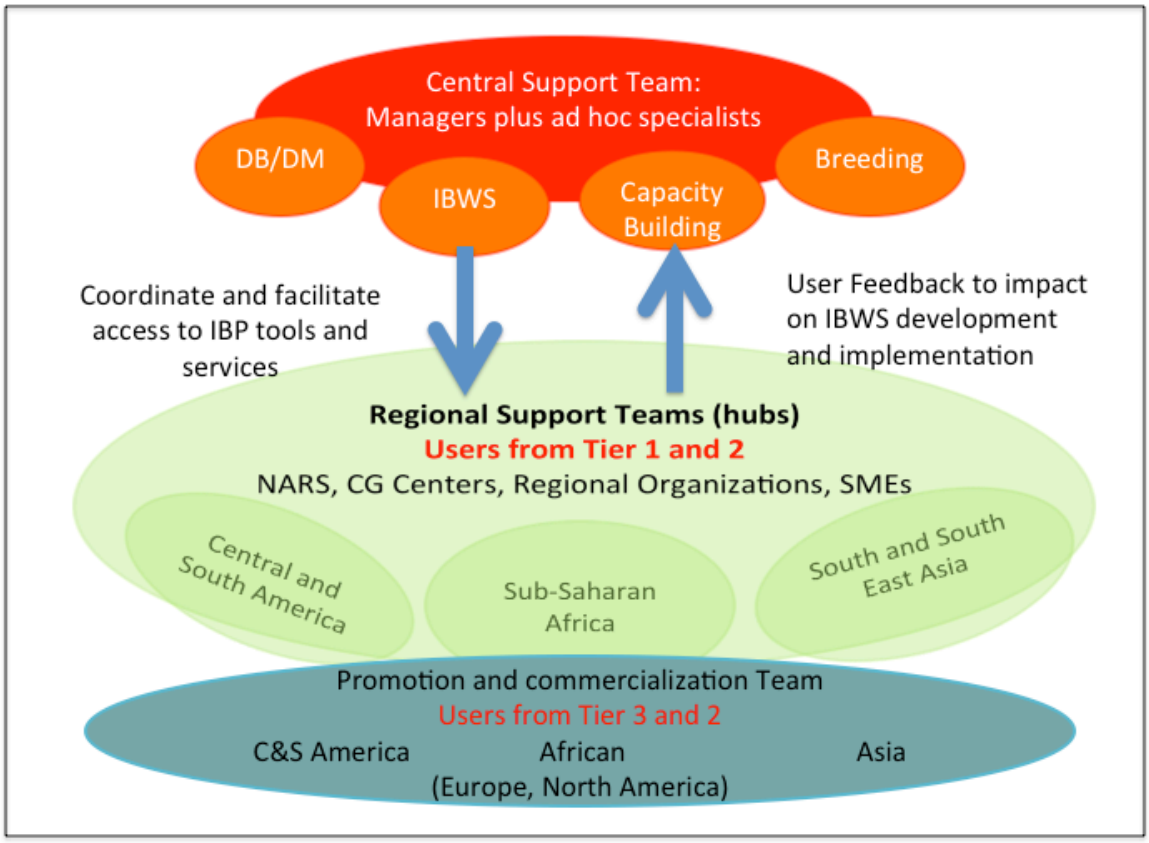
Training courses: The Integrated Breeding Multi-Year Course (IB-MYC) and other programmes provide skills-based training that addresses the practical needs of breeders, data managers, technicians

and field station managers in Sub-Saharan Africa and South & South East Asia. IB-MYC training covers molecular breeding, data management, and analysis.

Learning resources: Users can access useful in-house learning resources covering a variety of areas, including marker-assisted breeding, phenotyping, genomics & comparative genomics and genebank management. Access to third-party teaching and resources is also provided.

IBP organization

Discussions on the future institutional, governance and management arrangements for the Platform are proceeding in earnest, involving key stakeholders and donors. The finer details will be discussed with the selected host agent, with a view to maintaining the autonomy of the Platform while safeguarding the host institute and maximizing mutual benefits. It is envisioned to take the general operational format shown in the diagram below with a centralized team to be located at IBP HQ, working together with a number of regional hubs, located at strategic place all over the globe to help with the IBP promotion, use and adoption:



The Future[2]

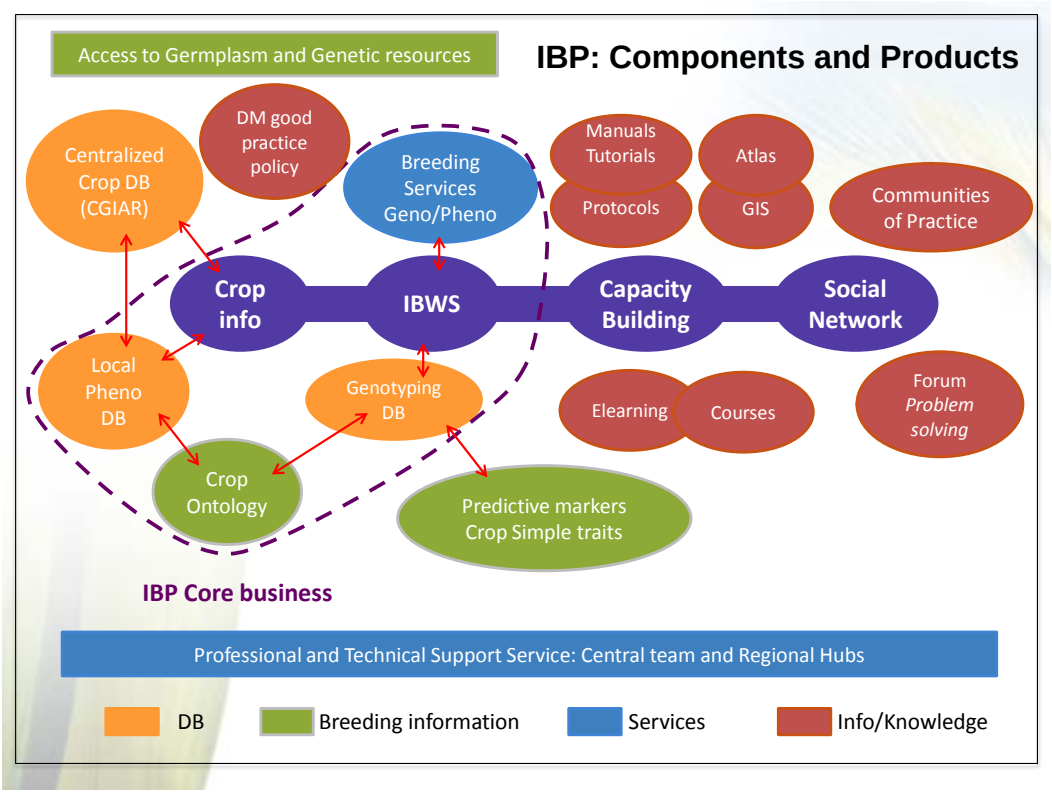
Negotiations with funders are at an advanced stage for financial support to the Platform post-GCP. As part of a sustainability strategy, the Platform is also proposed to engage closely with the private sector through structured partnerships designed to take advantage of that sector's acknowledged strengths in product delivery and user support. Regional hubs are also being established to support the roll-out,

[2] Click for more information on the post-GCP status of the Integrated Breeding Platform.

adoption and use of the BMS and the Platform as a whole, and will be an integral part of the Platform after GCP closes in 2014.

In the period 2015 – 2019, the IBP will endeavour to refine the various components and products. The key activities will be:

- Maintenance and improvement of the BMS and the portal
- Development of new functionalities for the BMS and database improvement
- Implementation of support services
- Proactive capacity building programme
- Promotion and awareness for general adoption



Conclusion

The Integrated Breeding Platform is addressing a real need, and is ideally positioned to advance and build on the legacy of the Generation Challenge Programme – facilitating the distribution of research outputs and preserving and extending multilateral partnerships. It is expected to attract and maintain funder support, with a secondary possibility of revenues from some activities.