The Boston Consulting Group (BCG) has undertaken an analysis of future ACT demand and artemisinin supply
- Integrated information from all available sources
- Pressure tested assumption
- Modeled multiple scenarios and sensitivities

BCG would like to thank the many stakeholders and experts that provided input to this work
- See final page for a complete list

This study was undertaken on behalf of the Bill and Melinda Gates Foundation

Our goal for this document is to share our analysis of:
- ACT/Artemisinin market
- Potential supply shortages in the near future
Key findings

1. Demand for ACTs expected increase to ~275M treatments per year by 2015
   • AMFm uptake is main cause of increase in demand
   • Potential decrease in treated malaria cases due to better interventions and diagnostics not expected to impact ACT demand until after 2015

2. Under current conditions, artemisinin supply will not be stabilized in the future
   • Based on the existing market dynamics, artemisinin supply will go through boom-bust cycles
     – Shortages & price spikes followed by oversupply and unsustainably low prices
   • Driven by two factors in the current supply chain:
     – Lack of credible demand forecasts
     – Long agricultural production time (2 yrs)

3. Present level of artemisinin cultivation (∼7,000 HA) is not enough to meet current demand
   • Cultivation has dropped off dramatically since 2006 and safety stocks will be consumed over the next two years
   • ∼23,000 HA of cultivation are needed to meet peak demand in 2015
   • This level of cultivation was reached in 2006, but only after prices spiked to over $1000/kg

4. Without intervention, artemisinin supply shortage likely in 2011/12
   • Lack of credible ACT demand forecast makes manufacturers reluctant to engage in long-term contracts
   • High food prices have made alternative crops more attractive to farmers
   • Large numbers of extractors going bankrupt in the past makes financing difficult to secure for remaining players
Agenda

Market overview

• ACT demand forecast and assumptions
• Supply forecast and assumptions
• Market outlook: present-2020
• Near term Artemisinin situation: 2010-2011
Market dynamics based on Supply and Demand analysis

Demand
- Existing demand forecasts based on GFATM grants, AMFm and malaria cases
- Triangulate between sources: CHAI, MIT/Zaragoza, UNITAID/McKinsey, GMAP
- Scenarios and sensitivities:
  - AMFm ramp up, resistance, product mix and declining malaria incidence

Supply
- Supply projection based on hectares planted & inventory stock of Artemisinin
- Triangulate between data sources
  - CHAI, artepal and industry
- Estimate future planting based on historical price-supply curves

Baseline ACT and artemisinin needs
- Artemisinin/ACT supply situation
- Treatment shortage
Demand analysis: Strong increase in ACT demand expected over next 5 years

Total ACT Demand

- ACTs delivered (actual)
- Demand forecast scenarios
- Demand forecasts from other groups

- MIT-Zaragoza Discounted
- CHAI Baseline (April 09)
- BCG Baseline
- UNITAID / McKinsey
- Slow AMFm Ramp up
- Increased public sector demand & faster AMFm
- No AMFm (public sector only)

ACTs delivered (actual)
Demand forecast scenarios
Demand forecasts from other groups

03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20

Millions of treatments

0 50 100 150 200 250 300 350

ACTs delivered

Malaria Cases (millions)

- 247 in 2006
- 135 in 2020 GMAP target

Note: 2008 Actual treatments projected from actual Novartis distribution of Coartem and assuming constant market share

(†) Recently updated CHAI baseline
AMFm launch main driver of ACT demand increase

AMFm demand scenarios

- Baseline scenario assumes Phase 2a and 2b countries launch at different times:
  - Phase I starts in Q1 2010 and includes the following countries: Benin, Cambodia, Ghana, Kenya, Madagascar, Nigeria, Rwanda and Uganda
  - Phases II.1 and II.2 start in Q1 2012 and Q1 2013 respectively and include the next remaining 30 countries that make up 95% of malaria cases worldwide
- Uptake modeled under 2 year S-curve reaching maximum of 50% private sector market share (of all malaria drugs)
  - Previous Tanzania trial reached 60% in 5 months but only covered two districts and used more attractive packaging than will be used under complete rollout
- Remaining scenarios shift either phases, start dates or uptake speed

Scenario assumptions

Millions of treatments

- CHAI Baseline (April 09)†
- MIT-Zaragoza Discounted
- UNITAID / McKinsey††
- BCG Baseline


(†) Recently updated CHAI Baseline
(††) UNITAID / MCKinsey includes premium private sector demand
### BCG Baseline demand assumptions

<table>
<thead>
<tr>
<th>Assumption</th>
<th>Baseline</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Public Sector</strong></td>
<td></td>
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<tr>
<td>Global Fund Rounds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Round 8</td>
<td>$2.6B</td>
<td>• Expected disbursements predicted using CHAI dynamic model</td>
</tr>
<tr>
<td>• Round 9</td>
<td>$400M</td>
<td></td>
</tr>
<tr>
<td>• Round 10</td>
<td>$800M</td>
<td></td>
</tr>
<tr>
<td><strong>Other public sector donors</strong></td>
<td></td>
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</tr>
<tr>
<td>AMFm Phase I</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Start date, Countries</td>
<td>Q1-2010, 8</td>
<td>• Application approvals scheduled for Sep 2009</td>
</tr>
<tr>
<td>AMFm Phase II (part 1)</td>
<td></td>
<td>• 8 of the 11 selected countries will join Ph.I</td>
</tr>
<tr>
<td>• Start date, Countries</td>
<td>Q1-2012, 15</td>
<td>• 18 month length of Ph.I plus 6 months to prepare Ph. II.1</td>
</tr>
<tr>
<td>AMFm Phase II (part 2)</td>
<td></td>
<td>• Ph.II.2 starts one year after Ph.I.1</td>
</tr>
<tr>
<td>• Start date, Countries</td>
<td>Q1-2013, 15</td>
<td>• The 38 countries included in the AMFm make up 95% of malaria cases worldwide</td>
</tr>
<tr>
<td>AMFm uptake</td>
<td>S-curve reaching 50% market share over 2 years</td>
<td>• Tanzania trials ramped up to 60% in 5 months but only in two districts and with more attractive packaging than will be used in future</td>
</tr>
<tr>
<td>Premium private sector</td>
<td>12M treatments in 09, ramps down as AMFm ramps up</td>
<td>• Based on CHAI dynamic model (see appendix slide 6 for detail)</td>
</tr>
<tr>
<td><strong>Private Sector</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Overall</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long term ramp down</td>
<td>ACT treatments begin decrease after 2015 due to decrease in Malaria cases</td>
<td>• Based on GMAP model’s prediction of impact of diagnostic and preventative measures (RDTs, vaccines, bednets)</td>
</tr>
<tr>
<td>Artemisinin requirements</td>
<td>2 Million treatments of ACT per tonne of Artemisinin</td>
<td>• Based on average dosage for Coartem treatment and Artemisinin required per dosage (see appendix slide 7 for detail)</td>
</tr>
</tbody>
</table>
Supply Model: We forecast future supply based on current stock & anticipated responses to future market conditions

Demand and supply of Artemisinin

**Variable Production**¹
- Price level in year 1 determines planting level in year 2, which determines production in year 3
- Price in any given year is a function of demand level that year and is
  - magnified in the case of a supply shortage
  - decreased in the case of excess supply

**Other assumptions**
- 0.8% yield (art. content in leaves)
- 2M ACTs / MT artemisinin

**Safety Stock**
Overproduction in 2007/8 resulted in ~85 MT excess stock in supply chain, which is used to cover demand in 2009/10

**Minimum Production**
- 2009 planting of 7,000 HA drives 2010 artemisinin production
- We assume this establishes future “floor” of committed farmers since price in 2008 was below estimated cost of cultivating artemisinin

1. See appendix slide 16 for detailed model logic
## Baseline supply assumptions

<table>
<thead>
<tr>
<th>Assumption</th>
<th>Baseline</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Existing supply</strong></td>
<td></td>
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<tr>
<td>Current safety stock Tonnes</td>
<td>85 tonnes</td>
<td>• Based on information from Malcolm Cutler, Sanofi, and Novartis</td>
</tr>
<tr>
<td><strong>New planting</strong></td>
<td></td>
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<tr>
<td>2009 planting Hectares (HA)</td>
<td>7,000 HA</td>
<td>• Mid-level range of CHAI estimates (Nov. 2008) and Artepal findings (March 2009)</td>
</tr>
<tr>
<td>Minimum future planting HA</td>
<td>7,000 HA</td>
<td>• Estimated as the level of current long term contracts. Since prices in 2008 were below estimated cost of cultivation and planting was ~7,000 HA</td>
</tr>
<tr>
<td>Farmer decision criteria</td>
<td>-</td>
<td>• Planting level is based on prior year’s demand and supply shortage/excess (see appendix slide 16 for model logic)</td>
</tr>
<tr>
<td><strong>Planting yield</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land yield tonnes leaves/HA</td>
<td>1.5 tonnes/HA</td>
<td>• Midpoint of Artepal range; conservative end of M. Cutler estimate of 1.5 – 4.5</td>
</tr>
<tr>
<td>Leaf yield Kg art./ Kg leaves</td>
<td>.8%</td>
<td>• Range within estimates from Artepal, M. Cutler, CNAP, and extractors (0.4-1.2%), 0.8% is average yield in China today</td>
</tr>
<tr>
<td>Purification process efficiency</td>
<td>50%</td>
<td>• Midpoint of 40% - 60% range provided by Artepal</td>
</tr>
</tbody>
</table>
Lack of credibility in demand forecast and long lead times cause cycles of supply excess and shortage

- ACT demand peaks at 275 Million treatments in 2014
- Artemisinin demand reaches 135 tonnes
- Production peaks at 178 tonnes (30,000 HA) in 2014, as a result of price spike in 2012

Without intervention, supply shortage will occur in 2011/2012 and will cause a significant price spike

• Current levels of production are not enough to meet demand in 2009/2010. Instead safety stock will be consumed.
• Lack of credible demand forecasts causes manufacturers to place few orders with extractors

Our current view of the Artemisinin situation


2010
Supply of Artemisinin likely to be sufficient to meet ACT demand

Some sources have predicted shortage or tight supply will be tight
- We feel a shortage is unlikely given the most probable set of supply data and demand assumptions
- Wild leaves would be able to make any potential small gap

Three critical factors:
(1) Amount of safety stock held in the supply chain today
(2) Amount of Artemisia currently cultivated
(3) AMFm uptake Phase I countries

2011
Artemisinin shortage probable unless the supply situation improves

Companies will deplete majority of safety stock to meet 2010 demand
Even with delayed AMFm demand will outstrip growing projected growing capacity available in 2011
Significantly increase in area under cultivation needed in 2010 to meet expected demand

2012-2015
Significant increase in supply needed to meet steady state demand

Cultivated Artemisia needs to increase to 23,000 hectares (vs 7,000 today)
- Assuming that AMFm ramps to cover 50% of the private anti-malarial market in 38 highest burden countries
Historically, prices needed to reach $1,000 / kg to attract this many farmers/extractors to the market
- Unclear what price point would be required to stimulate this level of growing in future
New technologies may begin to affect artemisinin supply in this timeframe
### Action needed to ensure supply in 2011/2012

Shortage in 2010 is unlikely given current AMFm schedule

### Scenario Analysis

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Demand scenarios</th>
<th>Supply scenarios</th>
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<tbody>
<tr>
<td><strong>Baseline</strong></td>
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<tr>
<td>BCG Baseline</td>
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<tr>
<td>AMFm Phase I delayed by 1 year</td>
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<tr>
<td>AMFm in 2 Phases</td>
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<td></td>
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<tr>
<td>No AMFm</td>
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<tr>
<td>1.75M treatments per tonne of Artemisinin</td>
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<tr>
<td>2.25M treatments per tonne of Artemisinin</td>
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<tr>
<td>Public sector +20% &amp; faster AMFm</td>
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<tr>
<td>Public sector -20%</td>
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<tr>
<td>Lower safety stock (-30%)</td>
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</tr>
<tr>
<td>Higher safety stock (+30%)</td>
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<tr>
<td>2010 Planting 14,000 HA (2X 2009 planting)</td>
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<td></td>
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<tr>
<td>2010 Planting 5,000 HA</td>
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<tr>
<td>Artemisinin yield 1%</td>
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<td>Artemisinin yield 0.6%</td>
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<td>Artemisinin yield 1% &amp; 2010 planting 14,000 HA (2X 2009 planting)</td>
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</tr>
</tbody>
</table>

### 2009-2012

- **2009**: Base-line
- **2010**: AMFm Phase I delayed by 1 year
- **2011**: AMFm in 2 Phases
- **2012**: No AMFm

#### Wild leaves could supply additional 20M+ treatments

- **Demand scenarios**
  - Remaining stock: Millions of treatments
  - Shortage: Millions of treatments

- **Supply scenarios**
  - Artemisinin yield 1%
  - Artemisinin yield 0.6%
  - Artemisinin yield 1% & 2010 planting 14,000 HA (2X 2009 planting)

**Millions of treatments**

- **2009**: 110
- **2010**: 44
- **2011**: -42
- **2012**: -105

**Backup**
Acknowledgements

We would like to thank the following individuals who provided their input:

**CHAI** – Justin Cohen, Sanjay Patel and Inder Singh
**FSC** – Malcolm Cutler
**GSK** – Richard Ansboro
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**MIT/ Zaragoza** – Michael Laverty and Prashant Yadav
**MMV** – Ian Bathurst, George Jagoe and Tim Wells
**Novartis** – Silvio Gabriel
**Oteci/Artepal** – Jacques Pilloy
**Sanofi** – Naomi Binoche, Philippe Farabolini, Henri Farret, and Florence Marchal
**WHO** – Andrea Bosman
**York / CNAP** – Dianna Bowles, David Clayton and Ian Graham